SCIENCE ABSTRACTS.

Section A.—PHYSICS

APRIL 1922.

GENERAL PHYSICS.

684. *Simple Micro-barograph.* **A. Wechsler.** (Nature, 108. p. 469, Dec. 8, 1921.)—The apparatus consists of a vacuum flask provided with a cork through which pass a capillary tube and a tube provided with a tap. A small drop of liquid is introduced into the capillary, and with the tap open, the drop can be made to occupy any desired initial position. The tap is then closed, and the movements of the drop following changes in the volume of the enclosed gas will indicate very small changes of pressure. The capillary must, of course, be kept level during the observations. Using a flask of capacity 450 cm.^{3}, a capillary of 0·3 mm.^{2} cross-section, and a drop of light paraffin oil as indicator, it was found possible to demonstrate the change of atmospheric pressure due to a change of vertical height of 1 ft. A. W.

685. *Comparator for a Vertically-placed Standard Metre.* **G. Dimmer.** (Akad. Wiss. Wien, Ber. 129. 2A. p. 223, 1920. Zeits. Instrumentenk. 42. pp. 24–27, Jan., 1922.—Abstract.)—Hooke's law would give a different length for a metal standard metre according as it lies horizontal or vertical. This difference in length is known from given values of Young's modulus. The apparatus actually used to measure this difference consists of a frame carrying the metre, which can rotate on a horizontal axis on a large graduated circle attached to a vertical wall. Measurements of the length are made with microscopes as in the ordinary comparator. The results for metres of steel, iron, and platinum are in general agreement with Hooke's law. P. E. S.

686. *Temperature Indicator for Pilot-Balloons.* **L. W. Pollak.** (Meteorolog. Zeits. 38. pp. 209–212, July, 1921.)—The need for a rapid means of determining the temperature of the upper air, brought into prominence during the Great War in connection with forecasting and artillery work, led by stages described in the paper to the development of an instrument which can be attached to a pilot-balloon and set in such a way as to signal when the balloon has reached a level where the air has a given temperature. A smoke-signal is used by day and a light-signal by night, these being seen through the theodolite with which the pilot-balloon is followed. The height of the balloon when the signal is made is determined by any of the methods ordinarily employed in upper-wind measurements. When visible signals are useless owing to cloud, sound-signals may be employed.

The essential feature of the instrument is a narrow tube filled with water, sealed securely at one end and closed at the other by a silver membrane. When the balloon reaches a level where the temperature is 0° C., the water freezes and in expanding distorts the membrane, thus completing an electric circuit and firing a charge. The freezing may be arranged to take place at a lower temperature by using a salt solution of known concentration. A label attached to the instrument requests the finder to return it. A scale drawing is given in the paper. M. A. G.

687. *Measurements with Double-Pendulum.* **R. Schumann.** (Zeits. Instrumentenk. **41.** pp. 352–355, Dec., 1921.)—Describes with figures a special form of double pendulum, having an adjustable yoke, which is useful in geodesy. E. H. B.

688. *Verification of International Metre Standards.* **C. E. Guillaume.** (Comptes Rendus, 173. pp. 1438–1443, Dec. 27, 1921.)—After the first International Conference at Sèvres in 1889 it was decided to make a certain scale (metre No. 6) the Prototype international metre. It was then put aside in a special room with two "witness" scales (metres No. 13 and I_2); two other scales (metres No. 26 and T_3) were put aside for use in all the important comparisons of metres at the International Bureau; and these two scales have been continually used thus.

In 1889 after the Conference the countries which adhered to the convention of the metre received from Sèvres their national metres standardised against the Prototype.

In 1914 the various national metres were called in for intercomparison; but the work on them was not commenced till 1919. Since then measurements of length and dilatation have been conducted, with the unexpected result that the national standards all appear to have shortened relative to Nos. 26 and T_3 in the interval 1889–1919. The "witness" scales (13 and I_2) and finally the Prototype itself were brought out for comparison with all the others and with one another. The results obtained were that the relative equations of length of the Prototype and its "witnesses" remained unchanged in the intervening 30 years; whereas the scales 26 and T_3 have elongated.

The measurement of dilatation is now much more correct than was possible in 1889, and it is found that to some degree and for some temperatures the errors made in total length of the metres in the period 1889–1919 are corrected by the errors which were made in dilatation. It is supposed that the elongation observed in the metres 26 and T_3 is due to small shocks given to them when they were frequently placed on their geometrical supports in the comparator, even though they were always handled with great care. All these results show the need of careful redetermination of values, especially of a redetermination of the wave-length of light as conducted by Benoit, Fabry, and Perot in 1906.
P. E. S.

689. *Curvature Measurements.* **J. Guild.** (Optical Soc., Trans. 22. 3. pp. 127–137; Disc., 137–138, 1920–1921.)—The paper contains a description of the arrangements of well-known methods of spherometry which the author has found most suitable for accurate determinations, and also of a new microscope method suitable for medium and large curvatures. AUTHOR.

690. *Theory of Longitudinal Vibrations of Viscous Rods.* **W. G. Cady.** (Phys. Rev. 19. pp. 1–6, Jan., 1922.)—*Vibrations of Thin Rods, taking into account Damping.*—Starting with the general differential equation of wave-motion in one dimension including a viscosity term, expressions are derived for the wave-velocity and logarithmic decrement in the case of *free vibrations* of the rod. The velocity is practically the same as for undamped vibrations, while the decrement is proportional to the viscosity and to the frequency. The equation is also solved for the case of *forced vibrations due to two simple harmonic forces at the ends*, equal in amplitude but opposite in phase. If the damping is small and frequency, $\omega/2\pi$, is near the resonance frequency, $\omega_0/2\pi$, the expression for the displacement of the end of the rod is very simple: $\xi = (4X_0 l/\pi G\delta) \cos \theta \sin (\omega t - \theta)$, where $\tan \theta = -2\pi(\omega_0 - \omega)/\omega_0\delta$, δ is the logarithmic decrement per period, l the length of the rod, X_0 the maximum value of the periodic stress, and G Young's modulus. It is shown that this expression may also be obtained by reducing the rod to an equivalent system possessing one degree of freedom. AUTHOR

691. *Notes on the Method of Dimensions.* **E. Buckingham.** (Phil. Mag. 42. pp. 696–719, Nov., 1921).—It is pointed out that a less intuitive and more systematic procedure in the dimensional method of analysing physical problems is desirable and is provided by formulating the requirement of dimensional homogeneity as a general algebraic theorem, which was first published by Riabouchinski, and a statement of which is given. Certain questions arise, as, for example, the following:—(*a*) How is it to be known that the initial equation is complete, i.e., that the list of quantities is sufficient for the problem in hand? (*b*) Are dimensional constants to be regarded as "quantities"? (*c*) How are universal constants, *e.g.*, Joule's equivalent, the speed of light, the gravitation constant, to be treated? (*d*) How many fundamental units are needed? These questions are investigated in reference to particular physical examples, illustrating the application of the method. A. B. C. L.

692. *Number of Pieces of a Plate broken by a Blow.* **S. Suzuki.** (Phys. Math. Soc. Japan, Proc. 3. pp. 168–174, Dec., 1921.)—Describes experiments to determine the number of pieces into which circular plates of various materials are broken by blows from spherical steel balls of various weights travelling with different velocities. The materials investigated were sealing wax, plaster of Paris, and clay, and it was found that in every case the number of pieces increased as the velocity of the projectile was increased. When the blow was central the pieces were all of the same shape and the cracks symmetrically disposed radii of the disc. J. W. T. W.

693. *On the Unity Problem of Physics.* **T. Kaluza.** (Preuss. Akad. Wiss. Berlin, Ber. 54. pp. 966–972, 1921.)—In the general theory of relativity, there must enter for the characterisation of the world phenomena the electromagnetic potential q_μ in addition to the fundamental tensor $q_{\mu\nu}$ of the four-dimensional continuum. The present author discusses this apparent dualism of gravitation and electricity, in order to arrive at a unitary world-picture. Weyl's radical revision of the geometrical basis respecting the tensor $q_{\mu\nu}$ is referred to, since the author proposes to arrive at the same result by an alternative method. The paper is mathematical throughout. H. H. Ho.

694. *Calculations for Beams with Loads Irregularly Distributed.* **T. Thompson.** (Engineering, 112. pp. 656–658, Nov. 11, and pp. 686–689, Nov. 18, 1921.)—Describes a method of calculating the distribution of shearing force, bending moment, inclination and deflection along beams with any arrangement of loading. The loading curve is first analysed into a series of sines and the effect of each term of this series is separately computed. Examples of the application of the method to actual problems are given in the paper. It is generally found that harmonics higher than the fifth may be neglected for an accuracy of 1 %. The application of the method to beams of non-uniform section, as well as the process of smoothing out the load-intensity curve in the case of discontinuous load systems, are described in the latter part of the paper. J. W. T. W.

695. *Duration of Impact of Bars.* **E. W. Tschudi.** (Phys. Rev. 18. pp. 423–430, Dec., 1921.)—*Impact of Two Spheres.*—The Hertz theory was verified by *experiments* with brass and cast-iron spheres of 3·8 and 7·6 cm. diam. respectively, using a condenser discharge method of measuring short time intervals which gave accurate results for intervals of the order of 10^{-4} sec.

Impact of Bars.—*Experiments* with hot-rolled steel bars, 2·86 cm. in diameter and 16 to 62 cm. long, prove that the compressional wave theory is inadequate since the duration of impact was found to be a function of the initial velocity and to be proportional, not to the first power of the length of the shorter bar, but more nearly to the two-fifths power. Moreover, the fundamental assumption of the compressional wave theory was shown to be wrong by means of a model in which the wave velocity was slow enough to be observed. A *theoretical expression* was then derived on the basis of certain assumptions as to the distribution of pressure and its variation with the displacement of the centre of mass of the colliding body, which agrees in general with the experimental results. AUTHOR.

696. *Deformation Waves.* **K. Uller.** (Zeits. f. Physik, 6. 4. pp. 298–302, 1921.)—A general descriptive enumeration and discussion of various kinds of related or possible waves in solids and fluids. E. H. B.

697. *Cylindrical Spiral Springs and Technical Theory.* **J. Andrade.** (Comptes Rendus, 173. pp. 697–698, Oct. 24, 1921.)—The theories of Philipps and of Résal-Caspari are compared with technical theory, particularly in respect of associated spirals, as applied to the isochronism of escapements. A. B. C. L.

698. *The Two Lorentz Coefficients of Inertia for High Velocities.* **G. Fontené.** (Comptes Rendus, 173. pp. 1066–1069, Nov. 28, 1921.)—Starting with the same order of fundamental ideas as that underlying the Lorentz transformation, an alternative line of reasoning is developed mathematically, to obtain the two inertia coefficients. A. B. C. L.

699. *The Tresca-St. Venant Theory.* **M. Brillouin.** (Ann. de Physique, 14. pp. 75–112, July–Aug., 1920.)

700. *Tests of Lateral Earth Pressures.* **G. M. Braune** and **J. Feld.** (Eng. News-Record, 87. pp. 314–316, Aug. 25, 1921.)—Describes the construction and use of a large experimental retaining wall 5 ft. × 6 ft. which fits into the open front of a concrete bin, for the measurement of the lateral thrust due to various fillings. The amount, direction, and point of application can be computed, and actual results with a sand filling give an excellent check with the values obtained by the formula, provided the angle of internal friction be used instead of the angle of natural slope. J. W. T. W.

701. *Propagation of Waves in an Isotropic Solid.* **A. Mallock.** (Nature, 108. pp. 465–466, Dec. 8, 1921.)—The nature of the effective elasticity determining the velocity of waves in an isotropic solid is considered in relation to the effects of boundary conditions. Where the coefficient of interior elasticity is denoted by B, $B = E/(1 - 2\mu^2)$, (E = Young's modulus, μ = Poisson's ratio). Curves are given showing the values of E and B as multiples of n (simple rigidity) in terms of μ. It is stated that in iron or glass $\sqrt{B} > \sqrt{E}$ by about 10 %. The dependence of the max. possible height of a precipice on the value of E for various materials is referred to. A. B. C. L.

702. *Radiographic Studies of Metals.* **M[argarete] Ettisch, M. Polányi,** and **K. Weissenberg.** (Phys. Zeits. 22. p. 646, Dec. 1, 1921. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—Becker, Herzog, Jancke, and Polányi having observed that hard-drawn copper wire does not give the full Debye-Scherrer circles, but only short arc-shapes, the authors use this method for the quantitative determination of the crystal arrangement in hard-drawn wires. The effect was also observed in wires of W, Fe, Mo, Cu, Pd, Al, Ag. The elements with cubical lattices (Fe, Mo, W) seem to have a single-fibre structure with diatropy of the plane (110); the cross-section shows only faces of rhombic dodecahedra. Elements with face-centred cubical lattices (Cu, Pd, Al) show a twofold-fibre structure with diatropy of the planes (111) and (100); there are therefore only octohedron and hexahedron faces in the cross-section. H. B.

703. *Existing Solutions of the Torsion Problem.* **T. Pöschl.** (Zeits. Math. u. Mechanik, 1. pp. 312–328, Aug., 1921.)—This report gives the fundamental equations of the problem of the torsion of a cylinder, and the torsion function and the " torsional rigidity " for the following forms of section :—circle, ring, ellipse, equilateral triangle, thin strip, rectangle, circular, and ring sector, curvilinear quadrilateral bounded by arcs of confocal ellipse and hyperbola, elliptical ring, eccentrically bored tube. Approximate solutions for the rectangle and girder sections occurring in practice are also mentioned, and a short bibliography is appended. W. G. B.

704. *Approximate Integration of the Differential Equation of the Limit Surface of Laminar Motion.* **K. Pohlhausen.** (Zeits. Math. u. Mechanik, 1. pp. 252–268, Aug., 1921.)—By assuming a power series for the velocity distribution near the wall, y including powers up to the fourth, approximate values for the thickness of the layer in which the velocity varies from that of the boundary to that of the corresponding potential solution are obtained, and compared with Heimens' exact solutions. W. G. B.

705. *Considerations on the Form of a Solid, and the Kinetic Energy of Fluid Surrounding it.* **D. Riabouchinski.** (Comptes Rendus, 174. pp. 212–215, Jan. 23, 1922.)—It is shown that if two bodies move with the same velocities in an infinite fluid, separately, the difference of the kinetic energies of the fluid in the two motions is less than the kinetic energy of a mass of fluid whose volume is the difference of the volumes of the solids, moving rigidly with the same velocity. W. G. B.

706. *Vibrations of a Rod of Variable Cross-Section.* **N. Mononobe.** (Zeits. Math. u. Mechanik, 1. pp. 444–451, Dec., 1921.)—After quoting the result for the frequencies of vibration of a cone obtained by Kirchoff, the case of a frustrum is worked out. The frequency equation involves Bessel functions of real and imaginary arguments, and solutions are obtained. The results are applied to several chimneys in Japan, and good agreement with experimental determinations, made for the "Earthquake Investigation Committee of Japan," is obtained. W. G. B.

707. *Solution of the Torsion Problem for a Rod with a Multiply-Connected Cross-Section.* **P. Neményi.** (Zeits. Math. u. Mechanik, 1. pp. 364–367, Oct., 1921.)—The problem is reduced to the determination of *n* functions. These can be individually determined by membrane experiments, and the linear combination of them which satisfies the boundary conditions can then be calculated. The stresses and the torsional rigidity of the section are thus obtained. W. G. B.

708. *Flow Phenomena in Extruded Brass.* **F. Doerinckel** and **J. Trockels.** (Zeits. f. Metallkunde, 13. pp. 466–472; Disc., 472–473, Oct., 1921.)—Sets of eight cylindrical blocks of brass, 145 mm. diam., 50 mm. high, are piled upon one another, but separated by seven discs of brass, 1·5 mm. thick, so as to form one big cylinder, the parts of which are held together by two brass bolts passing through the eight blocks. The whole is then extruded through a die with sharp edges, 60 mm. diameter, at 700° C. The cylinders are subsequently cut through axially at different stages of the extrusion, and the cut surfaces are etched with chromic acid. The blocks all contained 58 % of copper, but the bolts and the various discs were richer in copper, so that the lines of flow could be traced. In the central portion near the vertical axis the lines were drawn far out into the extruded part; near the circumference the material was little disturbed, the discs near the orifice keeping their mutual distances; those further away had actually receded and had been drawn inward. In some parts asymmetrical and torsional effects were also observed, partly due to local temperature variations; on the whole the phenomena were regular. Reference is made to the flow experiments of Schweissguth [Zeits. Vereines deutsch. Ing. 62. pp. 281 and 305, 1918], and of W. Schulte [Metallbörse, pp. 441 and 499, 1921]. H. B.

709. *Mechanical and Elastic Characteristics of Cast Irons and the Use of the Brinell Ball Test.* **A. Portevin.** (Rev. de Mét. 18. pp. 761–779, Dec., 1921.)—The results apply to semi-steel castings for shells. Tested in tension the elastic limit is a very variable quantity, in some cases there being no real range of proportionality. The results of tensile tests are so variable that this method of test is regarded as useless. In similar castings the max. stress varies from 7 to 26·7 kg./mm.^{2}, and the limit of proportionality from zero to 7·4 kg./mm.^{2}. It is of interest that the modulus of elasticity in tension is proportional to the max. stress, which fact has been used in testing the castings by a sonority test. As the casting is stronger the note becomes higher. This type of test is considered to have practical application. The relation is $M_t = 385R_t + 1150$, where R_t is the max. stress and M_t the modulus of elasticity—all in tension and in metric units. In compression the following relations have been observed: $R_c = 2·5R_t + 18$, $E_c = 0·2R_c - 20$, where R_c and E_c are the max. stress and elastic limit in compression respectively. For typical castings of semi-steel with a max. stress in tension of 25 kg./mm.^{2} the following results are obtained:—

Test.	Limit of Proportionality.	Max. Stress.	Deformation		
			in Length (per cent.)		in Section (per cent.).
			at Elastic Limit.	at Max. Stress.	
Tension	3·5 kg./mm.^{2}	25	0·3	0·5	0·16
Compression	12 kg./mm.^{2}	90	0·1	16	34

Brinell hardness tests are considered to be very useful, and the relationship to the max. stress in tension is given (for semi-steel) by the formula $R_t = 0·2\Delta - 13$, where Δ is the Brinell number under standard conditions. The formulæ in compression are: $R_c = \Delta/2 - 5$, and $E_c = 0·4\Delta - 25$. F. C. T.

710. *Endurance of Steel under Repeated Stresses.* **D. J. McAdam, Jr.** (Chem. and Met. Eng. 25. pp. 1081–1087, Dec. 14, 1921.)—Gives the results of endurance tests under repeated stresses of a variety of carbon and alloy steels after heat-treating in various ways, carried out at the U.S. Naval Engineering Experimental Station. For each type of steel, in addition to the endurance tests, tension, torsion, hardness, and impact tests were also carried out. The machine used for the endurance tests is a modification of the White-Souther machine, in which the specimen is arranged as a rotating cantilever beam. During every revolution of the specimen under test it is submitted to definite alternate tension and compression. An improved form of specimen is described in which the portion subject to stress is conical instead of cylindrical; the taper is so adjusted that the max. stress, instead of being at the end of the fillet, is in any desired plane. In plotting the results of the endurance tests, both stresses and cycles were represented by logarithmic co-ordinates. The advantage of logarithmic plotting is that it reduces the ordinates representing cycles to a convenient length; it has the disadvantage, however, that it minimises stress differences, especially at the higher stresses. When the object of the investigation is the determination of the effect of stress variations on endurance, the disadvantage of logarithmic plotting is rather serious, and for this reason in the present report semi-logarithmic plotting was finally adopted, the ordinates being made proportional to the stresses and the abscissæ to the logarithms of the numbers of cycles. Graphs of endurance test results on either logarithmic or semi-logarithmic paper show no evidence of abrupt change of direction throughout the cycle range investigated. Results of all the tests give cumulative evidence that the idealised stress-cycle graphs should be represented by nearly straight lines. The angles of slope of the semi-logarithmic graphs are such as to indicate that for this type of endurance test the drop in endurance stress with increase in number of endurance cycles is not nearly so rapid as has been previously supposed. The average drop with a thousand-fold increase in endurance cycles is about 15 %. The endurance stress of 100,000,000 endurance cycles bears no definite relation to the corresponding proportional limits. The ratio is higher in annealed material than in quenched and tempered material. In ingot iron and annealed mild steels of low carbon-content, the endurance stress for 100,000,000 endurance cycles is above the proportional limit. In quenched and tempered steels it is often less than half the proportional limit. The endurance stresses for 100,000,000 endurance cycles have been found to bear a surprisingly uniform relation to the corresponding ultimate tensile stresses. In the many kinds of material investigated, this ratio varies from about 0·35 to 0·54, the highest value being found in ingot iron. The average ratio is 0·44 ± 0·033. The ratios of endurance stress to Brinell hardness and to max. torsional stress are nearly as uniform as the ratio of endurance stress to ultimate tensile stress. Chemical composition appears to have little effect on endurance properties other than its effect on ultimate tensile stress, and a comparison of impact test results with the results of endurance tests has shown no definite relationship. C. O. B.

711. *Mechanical Properties of Metals (Mo, Ni, Al); Effects of Temperature, Deformation, Grain Size, and Rate of Loading.* **W. P. Sykes.** (Am. Inst. Mining Eng., Trans. [35 pp], Feb., 1921. Rev. de Mét. 18E. pp. 562–569, Nov., 1921.)—The metals molybdenum, nickel, and aluminium (alloyed with 3 % of copper) are chosen as representative. The tests were made on wires in a vertical electric furnace, consisting of an alundum tube, 2·5 cm. diam., 30·5 cm. high. Reference marks 2 in. (50·8 mm.) apart, were scratched with the aid of a diamond on the specimen, which was so suspended in the furnace that the lower furnace opening remained closed by a flange on the bottom clamp, and the pull was applied from above, the rate of displacement of the upper clamp being ⅛ in. or 1 in. per min. The temperature range is from liquid air (tube instead of furnace) up to 1000° (in an atmosphere of argon); baths of CO_2, boiling water, salts, etc., are used for intermediate temperatures. The specimens were all wires drawn down to 0·003 in. (0·63 mm.) diameter, but they were prepared in various ways. Thus some of the swaged molybdenum rods had originally diameters of ⅛ in. (3·1 mm.) and were reduced in cross-section by 93 % at temperatures of 1300° or less; the coarsest grains were 0·34 mm. in diameter, in other specimens there were 1100 or 35,000 grains per mm.^{2}; the grain was altered by thermal treatment in liquid metals, oil, and in hydrogen. The most complete series of tests was made with nickel. The curves of tensile strength, elongation, reduction of area, and also photomicrographs are reproduced (in the Rev. de Mét.) and references made to cognate researches, especially to recent experiments. The curves vary greatly with the treatment of the specimens. Nickel gave a max. strength of 158,000 lbs. per sq. in. (111 kg./mm.^{2}) in liquid air, molybdenum a maximum of 147·6 kg./mm.^{2} The influence of the rate of application of the stress upon the elongation is particularly marked at high temperatures, being in the case of Ni maximum near 900°; but there is an interval of 150 deg. in which the slowly-stressed nickel has a much larger elongation than the rapidly stressed. In general it may be said that the allotropic modifications influence the variations of all the properties. Apart from these and other specific characteristics, all the metals possess fundamentally the same properties which are functions of the temperature of observation. The greatest reduction in area by fracture in tension is observed in portions in which the whole cross-section is occupied by grains of a single kind; where two aggregates of grains are present, the finer grain undergoes greater contraction. An extremely low-temperature ductility is completely lost and the tensile strength probably diminished. Brittleness is first observed in metals of equiaxial structure; the finer the grain, the lower the temperature at which ductility still persists. Deformation of a metal below its annealing temperature makes the max. ductility, at any temperature below that of working, less than that of the same metal in the unworked condition; but the worked sample will retain its power of elongation to a lower temperature. The experiments were conducted in the Cleveland (Ohio) Wire Division of the National Lamp Works. H. B.

712. *Pressure and Velocity in the Wake of an Aerial Object.* **G. A. Crocco.** (Accad. Lincei, Atti, 30. ii. pp. 345–349, Nov. 6, 1921.)—Describes experiments to determine the velocity and pressure in the wake of an object in moving air. The objects tried were a thin circular disc and a rectangular prism supported in a wind channel. The residual velocity of the air in the aerodynamic "shadow" of the object thus tested gives the velocity lost in the case where the body is moving and the air stationary. The results are exhibited in the form of tables. It is found that the air in the wake of a moving body may acquire a velocity which is actually opposite in sense to that of the body itself. J. W. T. W.

713. *Influence of the Temperature on the Viscosity of Normal Liquids.* **E. van Aubel.** (Comptes Rendus, 173. pp. 384–387, Aug. 16, 1921.)—The dependence of the viscosity of a normal liquid on the temperature may be expressed by the equation, $\phi = m + n \log (\theta - t)$, where ϕ denotes the inverse of the viscosity, or the fluidity, t is the temperature of observation, θ the critical temperature of the liquid, and m and n are constants. Differentiation of this expression gives $-d\phi/dt = \text{constant}/(\theta - t)$, so that the increase in fluidity for a definite rise of temperature varies inversely as the difference between the critical temperature of the liquid and the temperature considered.
[Errata: *Ibid.*, p. 456, Aug. 29, 1921.] T. H. P.

714. *Criterion for the Stable Flow of a Fluid in a Uniform Channel.* **H. Levy.** (Roy. Soc. Edinburgh, Proc. 41. 2. pp. 136–147, 1920–1921.)—First shows that the non-dimensional group, vl/κ, may be used in the discussion of such problems, instead of the usual vl/ν. (κ is a vortex strength). The stability of a symmetrical pair of line vortices in a current between two parallel walls is considered. Instability is found if $vh/\kappa < (\pi/32) \tan^2 (\pi h/2a)$, $2h$ being the distance apart of the vortices, $2a$ the width of the channel. In the motion there is slip at the walls, and the above condition can be transformed into one implying a max. velocity of slip for stability. In the present state of experimental knowledge, it is uncertain whether this slip vitiates the applicability of these results to actual fluids. W. G. B.

715. *Experiments with Rotating Fluids.* **G. I. Taylor.** (Roy. Soc., Proc. 100. pp. 114–121, Nov. 1, 1921.)—Experiments are described and instantaneous photographs given verifying predictions made by the author on the motions of a cylinder, a sphere, and a vortex ring in a rotating fluid. As the predicted features of the motions do not depend upon conditions at the surfaces of solids, they are capable of experimental verification. Proof and experimental illustrations are given of the theorem that if a small motion be given to a mass of fluid rotating like a solid body, the resulting flow is two-dimensional. [See Abs. 286 (1917) and 1361 (1921).] W. G. B.

716. *Resistance to Flow of Fluids in Narrow Tubes.* **L. Schiller** and **H. Kirsten.** (Phys. Zeits. 22. pp. 523–528, Oct. 1 and 15, 1921.)—Discuss Sorkau's results (*ibid.*, 1911–1915, *passim*). The usual formulæ for laminar and turbulent flow, corrected for the kinetic energy of the issuing stream, are used to calculate the relations between discharge and pressure head, and these, together with Sorkau's results, are plotted for various liquids. It is found that for a Reynolds number (vr/ν) between 3500 and 4500, the experimental points leave the laminar curve and approach the turbulent one. The change is not sudden, since the point of the tube at which turbulence commences gradually approaches the inlet as the velocity increases. It is concluded that the evidence for assuming more than these two states of flow is very scanty. W. G. B.

717. *General Equations of Motion of Solid Bodies in a Perfect Incompressible Fluid.* **D. Riabouchinski.** (Comptes Rendus, 173. pp. 824–826, Nov. 7, 1921.)—A general mathematical investigation of which Thomson's theorem and Joukowski's theorem are particular cases. A. B. C. L.

718. *Laminar and Turbulent Friction.* **T. v. Karman.** (Zeits. Math. u. Mechanik, 1. pp. 233–252, Aug., 1921.)—Applies the idea, originally due to Prandtl, that the influence of viscosity in modifying the velocity distribution in a fluid is confined to a thin layer, to the determination of the resistance experienced in certain important cases. Starting from the experimental fact that the resistance to flow in a tube varies as the 7/4th power of the velocity (for large velocities), it is found that the velocity in the neighbourhood of the wall varies as the 1/7th power of the distance from it. This is in agreement with Stanton's measurements. This velocity distribution, when applied to the case of a plane moving endwise, gives a resistance coefficient $0{\cdot}072/R^{0{\cdot}2}$ (R being the Reynolds number, vl/ν), which agrees extremely well with the measurements of Gibbons and Wieselberger, made in the aerodynamical laboratories at Göttingen

The method is next applied to the case of a rotating disc, the resistance coefficient being found to be $0{\cdot}146/R^{0{\cdot}2}$, which agrees fairly well with Schmidt's results (Zeits. Ver. deut. Ing. 65. 1921). An application to canals with rough walls gives the law $v \propto m^{0{\cdot}64}\,\iota^{0{\cdot}5}$, agreeing with empirical formulæ found by various observers. W. G. B.

719. *Remarks on the Origin of Turbulence.* **L. Prandtl.** (Phys. Zeits. 23. pp. 19–23 ; Disc., 23–25, Jan. 1, 1922. Paper read at the Deut. Physikertag, Jena, Sept., 1921. Zeits. Math. u. Mechanik, 1. pp. 431–436, Dec., 1921.)—Records the results of a further attack on the problem of the stability of laminar motion by the well-known method of Rayleigh. The graph of the velocity, as a function of the distance, y, from the wall, was taken as a broken line. It appears that convexity to the y axis gives instability. The influence of viscosity in the disturbed motion is taken into account, and the boundary conditions are satisfied. This explains the origin of turbulence, but makes it difficult to explain the stability of laminar motion at all. Discussion centred on the lack of agreement of these results with observation. W. G. B.

720. *Hydraulic Régimes.* **C. Camichel.** (Comptes Rendus, 173. pp. 1061–1063, Nov. 28, 1921.)—Describes experiments in which surfaces of discontinuity, like the well-known case first given by Helmholtz, were actually obtained in the flow of water past an obstacle. Outside the surface the flow was non-turbulent. Inside (i.e., in the wake) the motion is turbulent, and the average pressures are given by the ordinary hydrostatic laws. The pressure is quite definite at the prow and stern, but is less so in the region where the surface of discontinuity leaves the solid. W. G. B.

721. *Variation of Energy around a Point of a Rotary Hydraulic Machine.* **D. Eydoux.** (Comptes Rendus, 173. pp. 1063–1066, Nov. 28, 1921.)—Obtains vectorial formulæ for the rates of change of energy of fluid during passage through a rotary hydraulic machine, and for the reactions of the vanes. W. G. B.

722. *Stability of the Steady Motion of Viscous Liquid Contained between Two Rotating Coaxial Cylinders.* **W. J. Harrison.** (Cambridge Phil. Soc., Proc. 20. pp. 455–459, Nov., 1921.)—A correction to a previous paper [see Abs. 590 (1921)].

723. *Equations of Motion of a Fluid with respect to Mobile Axes.* **D. Riabouchinski.** (Comptes Rendus, 173. pp. 698–701, Oct. 24, 1921.)—A mathematical study of the effect of the substitution in Euler's equations of motion, of the projections of accelerations upon mobile axes instead of upon fixed axes. A. B. C. L.

724. *Time in Classical Mechanics and in the Theory of Relativity.* **J. Le Roux.** (Comptes Rendus, 173. pp. 1074–1077, Nov. 28, 1921.)—The most contestable results of the theory of relativity depend for the most part on the definition of isochronism, according to Einstein. The notion is introduced of a certain parameter t differing in reality from ordinary time. In Einstein's theory, two observers are assumed to possess each an ideal chronometer with which they compare movements taking place in their immediate neighbourhood. In the notion of ordinary time, the chronometers are only auxiliary instruments of comparison, regulated by astronomical observations of the diurnal motion. The use of a chronometer becomes, in fact, the choice of a type movement with which other movements are compared. But whilst, according to Einstein, the type movement varies from one observer to another, in the ordinary conception of time, the type movement is the same for all observers. The effect of this consideration on the formulæ representing the phenomena of propagation by waves in an isotropic medium is treated mathematically.

A. B. C. L.

725. *The Relativity of Time.* **E. Esclangon.** (Comptes Rendus, 173. pp. 1340–1342, Dec. 19, 1921.)—Time has no other existence than that which results from the measurements applied to it, and different definitions of time are possible which permit of such measurements, but which may not be concordant with one another. A mechanical or celestial clock may be employed, luminous vibrations, biological or psychic phenomena, such as the beats of the pulse, the duration of a thought, the counting of numbers. These different methods are not necessary equivalents. It is necessary in every case to indicate clearly what definition of time is employed; otherwise results which appear contradictory or paradoxical will be obtained. For instance, on one assumption light travels with the same velocity in all directions, even when there is a motion of translation of the source. The contrary conclusion may be correct if another definition of time be chosen. Suppose that there is an eclipsing star at a very great (infinite) distance, then for an axis Ox at right angles to the direction of this star the regular eclipses being numbered will enable measurements of time to be made. This will also be true of any one-dimensional system $O'x'$ gliding along Ox, the time at each instant being defined by the number of the eclipse seen at that instant. It will, however, not be true if this method of measurement is adopted that the velocity of light in the direction of the Ox axis is independent of the sign and magnitude of the velocity of the source. Since the physical definition of time is necessarily more or less arbitrary, it follows that there is little meaning in speaking of two distant events as simultaneous in terms of such definition of time. It seems possible, however, to arrive at the idea of absolute simultaneousness, since, although according to the relativity theories matter cannot travel faster than light, it is possible to imagine phenomena which are displaced with larger velocities. For instance, a revolving lighthouse might send a spot of light on to a very distant screen, or an imaginary rotating machine-gun might pour a hail of projectiles on to a distant target. There is no limit to the velocity of the light spot along the screen or of the succession of the impacts on the target. These velocities are not velocities of propagation but of progression, and are theoretically measurable. Thus the *conception* of an infinite signalling velocity and, as a result of this, of absolute simultaneousness, seems justified. It is even possible by this means to show the experimental possibility of a continuous inversion of the relative time introduced into Lorentz's transformation. Let the luminous spot due to the distant revolving lighthouse travel on the screen Ox with a velocity u greater than c, the velocity of light. $O'x'$ is a screen moving on Ox with a velocity $v (v < c)$, t the local time for the fixed screen and t' that for the moving screen; it follows from the Lorentz formulæ that $x' = t'(u - v)/(1 - uv/c^2)$, and if v lies between c^2/u and $c(u > c)$ the ratio x'/t' is negative. The spot will appear to observers on O$'x'$ to move from right to left, while to those on Ox it moves from left to right, which implies a continuous inversion of time and corresponds to an experiment which can theoretically be realised if Einstein's relativity of time corresponds, not merely to a pure hypothesis, but to an experimental reality applicable to all the phenomena of Nature. H. N. A.

726. *Mechanism of the Surface Phenomena of Flotation.* **I. Langmuir.** (Faraday Soc., Trans. 15. pp. 62–72; Disc., 72–74, 1920.)—This paper is based mainly on the author's theory of surface phenomena, but also includes some experimental results.

Surface Tension.—The forces involved in the adsorption of organic substances with large molecules originates from certain atoms in the molecule and not from the molecule as a whole. An investigation of cleaned and of oiled glass surfaces shows that films one molecule in thickness are sufficient to alter radically the surfaces of solids, both as regards the lubricating properties of these films and the contact angles made by water drops.

Flotation.—The formation of froth depends on the presence of substances which can form a stable unimolecular film over the surface of each bubble. In order that a froth may readily form, it seems desirable to have present a soluble substance having a strong tendency to be adsorbed on the surface of the liquid.

Contact Angle of Solid Particles.—The tendency of particles to attach themselves to bubbles of the froth is measured by the contact angle formed between the oily surface of the bubble and the contaminated surface of the solid. The selective action by which substances like galena are separated from quartz and calcite is dependent on the contact angle formed by the oiled surfaces rather than on any selective tendency for the oil to be taken up by some minerals more than by others.

L. H. W.

727. *Relativity of Field and Matter.* **A. S. Eddington.** (Phil. Mag. 42. pp. 800–806, Nov., 1921.)—The paper consists mainly of general remarks and includes the development of an argument that if the electron that can exist at any place and time is on a particular and not on an arbitrary scale, or, more generally, if the statistical average of the electrons that may be formed at the point tends to a particular volume, then there exists at every point in the world a definite locus, viz., the boundary of the electron (averaged if necessary) which could potentially exist at that point. The general nature of this locus is discussed. A. B. C. L.

728. *Significance of Einstein's Gravitational Equations in Terms of the Curvature of the World.* **A. S. Eddington.** (Phil. Mag. 43. pp. 174–177, Jan., 1922.)—A more general proof is given of the theorem dealt with in a previous paper of the author [see preceding Abs.]. L. H. W.

729. *Transformation of the Equation of Motion of the Dynamics of Continuous Media in the Restricted Principle of Relativity.* **H. T. Flint.** (Phil. Mag. 42. pp. 794–799, Nov., 1921.)—The paper illustrates the application of a special mathematical notation [see Abs. 1522 (1921)] to the subject referred to in the title. A. B. C. L.

730. *Gravitation in Newtonian Mechanics and in the Mechanics of Einstein.* **P. Painlevé.** (Comptes Rendus, 173. pp. 873–887, Nov. 14, 1921.)—A detailed résumé of the fundamental postulates of the theory of gravitation in Newtonian mechanics, followed by a discussion of the theory of gravitation formulated by Einstein. Concordances and divergencies of the two theories are discussed in detail. A. B. C. L.

731. *Speed of Rotation and a Newtonian Proposition.* **G. Lippmann.** (Ann. de Physique, 16. pp. 165–173, Nov.–Dec., 1921.)—Postulating, for example, a rigid homogeneous sphere inhabited by observers deprived of exterior bodies of reference, it is shown how, by means of the geodesic pendulum, Foucault's pendulum, and the plumb-line, the speed and axis of rotation of the sphere can be determined on Newtonian principles. The theory is extended to the determination of the coordinates of a star, and, generally, to motions other than rotary motions and the absolute directions of trajectories. A. B. C. L.

732. *On Majorana's Theory of Gravitation; Suggested Explanation of his Experimental Result.* **H. N. Russell.** (Mt. Wilson Observat. Contrib. No. 216. Astrophys. J. 54. pp. 334–346, Dec., 1921.)—As a result of some delicate pendulum experiments, Majorana has suggested that gravitational force is weakened by passing through matter. In this paper certain *astronomical consequences* of this assumption are presented. The true masses of the planets according to this theory are computed and it is shown (1) that the inertial masses cannot be equal to these true masses, and (2) that if we assume them equal to the apparent gravitational masses we are led to such discrepancies in the case of the tides that we are forced to conclude that the absorption of gravitational force cannot exceed 1/5000 of the value assigned by Majorana.

Possible Influence of One Body on the Mass of Another Body.—The interpretation of Majorana's positive experimental result, assuming it to be real, must be that the mass of a body is actually changed by the presence of another body. AUTHOR.

733. *On Einstein's Gravitational Force.* **A. V. Bäcklund.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 15. No. 11. pp. 1–39, 1921.)—In Swedish. Mathematical.

734. *General Solution of the Static Problem of a Single Body on the Einstein Theory.* **A. Gullstrand.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 15. No. 8. pp. 1–15, 1921.)—In German. Mathematical.

735. *The Average of an Analytical Functional and the Brownian Movement.* **N. Wiener.** (Nat. Acad. Sci., Proc. 7. pp. 294–298, Oct., 1921.)—If a result is due to a number of causes whose contribution to the result is simply additive, then the result will remain unchanged if for each of these causes is substituted their mean. Now, the causes contributing to an effect may be infinite in number, and, in this case, the ordinary definition of the mean breaks down. In this case also some sort of measure may be used to replace number, integration to replace summation, and the notion of mean reappears in a generalised form. Now, there is a very important generalisation of the notion of a function of several variables, and, since a function is determined when its value is known for all arguments, a function of a function or functions, termed a functional, depends on an infinity of numerical determinations, and so may be regarded as in some wise a function of infinitely many variables. To determine the average value of a function is a practicable problem, provided that some convention exists as to what constitutes a normal distribution of the functions that form its arguments. Two essentially different discussions have been given of this matter: (1) by Gâteaux, being a direct generalisation of the ordinary mean in *n*-space; (2) by the present author, involving considerations from the theory of probabilities. The latter assumes that the functions forming the arguments of his functionals have as their arguments the time, and that in any interval of small length as many receive increments of value as decrements of equal size. The assumption is also made that the likelihood of a particle receiving a given increment or decrement is independent of its entire antecedent history. When a particle is acted on by the Brownian movement, it is in a motion due to the impacts of the molecules of the fluid in which it is suspended. While the retardation which a particle receives when moving in a fluid is due to the action of the individual particles of the fluid, it seems natural to treat the Brownian movement, in a first approximation, as an effect due to two distinguishable causes: (1) a series of impacts received by a particle, dependent only on the time during which the particle is exposed to collisions; (2) a damping effect, dependent on the velocity of the particle. One component of the total impulse received by a particle under heading (1) may be considered as a function of the time, and will then have the sort of distribution which will render applicable the theory of the average of a functional. The paper contains a detailed treatment of this problem, and is mathematical throughout. The result of the investigation is to show that Stokes' law is probably only a rough approximation, and that the resistance does not vary strictly as the velocity. H. H. Ho.

736. *Intermolecular Distances.* **R. Gans.** (Phys. Zeits. 23. pp. 108–113, March 1, 1922.)—The author deduces Hertz's result $R = 0 \cdot 5540/\sqrt[3]{(n)}$ for the most probable mean value of the intermolecular distance, where n denotes the number of molecules per unit volume of the substance, on the assumption that the molecules may be regarded as concentrated in mathematical points. The necessary modifications of this formula in various cases, when the finite size of the molecules is taken into account, are obtained and their application is illustrated by the calculation of the dimensions of the molecules and the van der Waals' constant b, in the cases of ethyl ether, ethyl alcohol, benzene, pentane, and the gases nitrogen, CO, CO_2, oxygen, and hydrogen. The ratios of the intermolecular distance to the molecular diameter are calculated in the case of the four liquids mentioned. These are respectively 1·05, 1·08, 1·09, and 1·085. It follows that, as the calculated intermolecular distance is the mean value, in the case of liquids, there must be actual contact between very many pairs of molecules. J. S. G. T.

737. *Crystallography and Lattice Structure of Metals.* **V. M. Goldschmidt.** (Zeits. f. Metallkunde, 13. pp. 449–455, Oct.; Disc., 518–524, Nov., 1921.)—A general article. As to the lattice the author distinguishes five types: (1) copper (also Ag, Au, Hg, Pb, Al, Th, Tl); (2) tungsten (Cr, Fe, Ni, which may also belong to (1)); the alkali metals form a group of (2); (3) diamond (also Si, Sn); (4) magnesium (Be, Co, Zn, Cd, Pd); (5) antimony (Bi, As); (5) and also (3) are more metalloidal. Attention is drawn to Westgren and Lindh, according to whom α and β iron belong to (1), γ iron to (2). The discussion by **Heyn, Osann, Rinne, Schenning,** and especially by **Guertler,** concerned also other papers and particularly mixed crystals, the modifications of iron, and mechanical twinning. H. B.

738. *Problems of Evaporation from Large Expanses of Water.* **M. A. Giblett.** (Roy. Soc., Proc. 99. pp. 472–490, Sept. 1, 1921.)—Air passing over a water surface is generally turbulent, but in the immediate vicinity of the surface is a thin superficial layer, which mixes only slowly with the air above. In this layer the humidity passes rapidly from saturation actually at the water surface to a lower value at the base of the turbulent region, after which the change with height is slow. The region where the lapse rate of humidity first becomes small is referred to as " near " the surface. To take account of the molecular processes at the water surface and in the superficial layer of air in contact with it, an empirical formula is chosen, expressing the rate of evaporation per unit area in terms of the temperature of the water surface and the vapour pressure and speed of the air " near " the surface. Taking this formula as expressing the boundary condition at the surface, the problem of the upward stirring of water-vapour in a current of air, of uniform speed, moving over a water surface of uniform temperature, is dealt with by mathematical analysis and the resulting distribution of water-vapour and rate of evaporation from large stretches of water are obtained. The turbulence is supposed uniformly distributed throughout the current of air above the level defined as " near " the surface, the coefficient of eddy-diffusivity in this region being taken as independent of height. Certain approximations are made, in that the rate of change with height of the air speed and density are neglected.

Finally, the effect of the wind speed, the water surface temperature, and the eddy-diffusivity, on the evaporation from a large stretch of water and the distribution of water-vapour above it, is examined by varying each individually within the natural range of values. The effect of eddy-diffusivity in particular, which may vary through a large range, is found to be very pronounced. AUTHOR.

739. *Pressure Maps at Three Kilometres in Japan.* **S. Fujiwhara.** (Monthly Weather Rev. 49. pp. 571–572; Disc., p. 572, Oct., 1921.)—The construction of isobaric charts for the 3-km. level has formed part of the daily routine of the Meteorological Service of Japan since March 1919. The method employed is one of great simplicity. Against each station is plotted the sum of the corresponding pressure and surface temperature, the former reduced to sea-level and expressed in mm. of mercury and the latter on the centigrade scale. Isopleths drawn for the figures so charted give the approximate course of the isobars at the 3-km. level. A brief demonstration of the reason for the success of this artifice is given. When the lapse-rate is not uniform the temperature employed should be corrected. A table of corrections can be made corresponding to different conditions, *e.g.*, fair weather, rainy weather, morning, evening, etc., actual observations of upper-air temperature being used in its construction. In the *discussion*, **C. Le Roy Meisinger** showed that by a change of units the pressure distribution at some other height is obtained. Pressure in millibars and temperature in degrees C. would give results for the 2-km. level. He expressed doubt as to the success of the method if applied to the large area of the United States with its wide range of conditions, mainly on account of the difficulty of tabulating corrections for departures of the lapse-rate from uniformity. M. A. G.

740. *Rainfall as a Function of Altitude in S.E. England and N.E. France.* **E. Mathias.** (Ann. de Physique, 16. pp. 305–310, Nov.–Dec., 1921. Paper read before the Assoc. Franç. pour l'Avancement des Sciences, Strasbourg.)—In a previous publication (*ibid.*, March–April, 1919) the author has investigated, for France, the relation between mean annual rainfall h and altitude A, finding for moderate altitudes a linear relationship $h = h_0 + k\mathrm{A}$, where the coefficient k is a function of latitude. The present inquiry shows, as expected, that the same values of the constants are found by applying the method to data for S.E. England as for N.E. France (Pas-de-Calais, Somme, and Ardennes), the actual formulæ obtained being respectively $h = 657{\cdot}8 + 1{\cdot}2\mathrm{A}$ and $h = 657{\cdot}1 + 1{\cdot}2\mathrm{A}$, where h is in mm. and A in metres. M. A. G.

741. *Correlation between the Fluctuations of Sun-Spot Area and Terrestrial Precipitation.* **S. Kunitomi** and **H. Takô.** (Central Meteorolog. Obs. Japan, Bull. 3. No. 3. pp. 95–125, 1921.)—This is a preliminary investigation of the relationship, if any, between solar activity, as indicated by sun-spots or faculæ, and precipitation in Japan. It arose through the discovery of a 7-day period in the latter which it was thought might correspond with a similar period in solar activity. The data employed refer mainly to one year only, and, the number of sun-spots being small, faculæ are almost exclusively considered. The results afford evidence of a parallelism which was best brought out by reducing, on certain assumptions, all observations of faculæ to the day of their central meridian passage. The relationship is, however, not at all marked in the "rainy season." Grouping the faculæ, reduced to the central meridian, according to their latitude, maximum frequency is found about 8° from the equator. An inquiry into the effect of the latitude of the faculæ on the terrestrial precipitation showed that the correlation is a minimum for those occurring at the equator, maxima being found about 15° to 20° from it, but at a distance varying from year to year. The correlation coefficients are, however, very small. M. A. G.

742. *Meteorology of the Antarctic. British Antarctic Expedition, 1910–1913. Meteorology : Vol. I. Discussion ; Vol. II. Weather Maps and Pressure Curves.* **G. C. Simpson.** (Calcutta : Thacker, Spink, and Co., 1919.)—(Nature, 106. pp. 526–528, Dec., 23, 1920.—Review.)—These volumes contain a discussion of observations extending over a period 1911–1913, for nine months of which weather maps, at 8 a.m. and 8 p.m. daily, are reproduced. Tables will form a third volume. The observing stations were at Cape Evans and Cape Adare, at Framheim, and for shorter periods at other places. The discussion embraces : temperature ; wind ; cloud and precipitation ; pressure and its relation to wind and weather ; general circulation ; upper air ; height of the Barrier and the plateau ;

and atmospheric electricity. The temperature records show that diurnal variation is not confined to the summer months but is quite definite when the sun is completely below the horizon, the " day " hours being, on the whole, warmer than the " night." Further, this is most marked on cloudy days, clear days showing two maxima at the times of minimum barometric pressure in the semi-diurnal wave, i.e., about 4 a.m. and 4 p.m. A second feature of the temperature régime is that, on the Barrier, the annual variation is " oceanic " in amplitude and " continental " in phase, while, by contrast, the reverse is true of the Arctic. Wind observations were obtained by Dines pressure-tube anemometer and show many interesting features. Gustiness at Cape Evans was found to be 50 % greater than at Scilly or Holyhead, but it decreased as the average wind speed increased. Pressure variations shown by surface records are interpreted as due to the propagation outwards from the centre of the Antarctic continent, of pressure-waves in the upper atmosphere, and in support theoretical synoptic charts are constructed in good agreement with those based on observations. In this connection, too, the view is expressed that blizzards, whatever their origin, are not associated with the circulation round the cyclones of the southern part of the temperate zone. As regards general circulation the Antarctic continent is anticyclonic at sea-level encircled by a low-pressure belt in lat. 65° S. At 10,000 ft. the anticyclone persists over the plateau, but pressure is low over the remainder of the Antarctic. Twelve good " ballon-sonde " records were secured on ten different days, but none reached the stratosphere. The summer records show a steady lapse of about 6° C. per km., while the winter records show a surface inversion between one and two km. thick. The lowest free-air temperature recorded was −51° F. at 22,000 ft. Dec. 25, 1911, while on the Barrier −76° F. was registered on July 6, the lowest recorded anywhere in the Antarctic. M. A. G.

743. *Fixed Glacial Anticyclone Compared to the Migrating Anticyclone.* **W. H. Hobbs.** (Am. Phil. Soc., Proc. 60. 1. pp. 34–42, 1921.)—G. C. Simpson, in the report on his meteorological work in the Antarctic during Capt. Scott's last expedition [see preceding Abs.], agrees with Meinardus that the descending air in the polar anticyclones is very poor in water-vapour and regards Hobbs's theory of glacial anticyclones [Abs. 1538 (1920)] as failing in one particular, i.e., in leaving unexplained the origin of the precipitation and the mechanism of the blizzards within the anticyclone. The present paper is a re-statement of the more essential elements of the author's conception of the glacial anticyclone, pointing out how the domed surface of the glacier is essential to the theory of the anticyclone and the alternating calms and blizzards associated with it, and that the origin of the precipitation in the blizzard itself has been elaborated in his paper as a " necessary inherent quality " of the anticyclone. The view is expressed that within the eye of the anticyclone is a region of light, variable winds, and excessively high humidity, whereas farther out are air currents with relatively low humidity. Evidence from a number of polar expeditions is adduced in support.

The essential characteristics of ice-dome as contrasted with ordinary anticyclones are classified as: (1) the fixed as opposed to the migrating position of the centre; (2) the location of the whirl above a glacier of domed surface; (3) the alternating calms and blizzards; and (4) the notably different distribution of humidity. M. A. G.

744. *Resistance of Air to the Movement of Spheres, and the Rate of Ascent of Pilot-Balloons.* **C. E. Brazier.** (Comptes Rendus, 173. pp. 644–646, Oct. 17, 1921.)—It is known from laboratory experiments that for a given sphere moving in air, the coefficient of resistance K (defined by $R = K\rho/\rho_0 \cdot \pi D^2/4 \cdot V^2$, where R is the resistance of the sphere, ρ the density of the air, D the diameter of the sphere, and V its speed relative to the air) depends on the value of the Reynolds number N ($= VD\rho/\eta$, where η is the coefficient of viscosity of the air). K is constant for $N < 100 \times 10^3$, and also for N greater than a number of the order of 300×10^3, the second constant value of K being less than the first. For N between these limits K varies and depends to a large extent on the degree of turbulence of the air.

With a view to testing this for pilot-balloons in the free air, the author has collected from various sources observations of the actual rate of ascent, made by the two-theodolite method or other means, and has computed, on certain assumptions, the corresponding values of K and N, with the following results :—

$N \times 10^{-3}$	≤ 100	$= 120$	$= 140$	$= 160$	$= 180$	$= 200$	$= 220$	$= 240$	$= 260 \geq 280$
$K \times 10^3$	51	50	47	44	41	38	35	32	29 27

These results show that the above conclusions from laboratory experiments are applicable to pilot-balloons. They are also comparable with those of Hesselberg and Birkeland on the rate of ascent of pilot-balloons within a large building, when the limiting values of N were found to be 130×10^3 and 200×10^3. This variation of the value of K explains the lack of agreement between the various formulæ which have been proposed for determining the rate of ascent from the weight of the balloon and its free lift, and the above figures should assist in determining the formulæ applicable in any particular case. M. A. G.

745. *Variation with Altitude of the Rate of Ascent of Pilot-Balloons.* **C. E. Brazier.** (Comptes Rendus, 173, pp. 756–758, Nov. 2, 1921.)—Observations in France have shown that, on an average, the rate of ascent of pilot-balloons decreases from the surface up to between 0·5 km. and 1·5 km., above which is a slow increase up to 8 or 9 km. This increase is, however, less than the theoretical value based on the ordinary law of resistance to a moving sphere. The difference is too great to be accounted for completely by loss of hydrogen or changes in the properties of the rubber with temperature. The author has previously demonstrated [see preceding Abs.] changes in the resistance of air to moving spherical balloons, of the magnitude required to explain the present discrepancy for the balloons in question, making some allowance for loss of hydrogen. It is suggested that in the free air, as in the laboratory, the resistance does not obey the quadratic law when the Reynolds number N ($= VD\rho/\eta$) lies between 10^5 and 3×10^5 and that it appears the Reynolds number must be considered not only in the calculation of the rate of ascent of pilot-balloons and the choice of their constants, but also in the deduction of the magnitude of vertical currents in the atmosphere from the observed rate of ascent by the two-theodolite method, for here a knowledge of the rate of ascent relative to the air is required. M. A. G.

746. *Natural Tendency towards Symmetry of Motion and its Application as a Principle in Meteorology.* **S. Fujiwhara.** (Roy. Meteorolog.

Soc., J. 47. pp. 287–293, Oct., 1921.)—The principle is expressed as follows: "Any revolving system in nature tends towards symmetry within the limits of its freedom." And this involves as a special case, "when any revolving fluid lies near to a plane boundary, its axis tends to become normal to that boundary." The boundary referred to may, in geophysical applications, be either the boundary between the atmosphere and land or water, or it may be a surface of discontinuity separating two air or water masses of different characters. The application of the principle is illustrated by examples of vortices in water, and of revolving systems in the atmosphere on all scales from individual vortical clouds, to thunderstorms, line squalls, cyclones, and the general circulation. In all cases it is shown how vortices are the mechanism by which a condition of asymmetry is transformed into one of uniformity, the vortices themselves being asymmetrical when first formed, later tending towards symmetry as they approach their death, dissipating the energy originally absorbed. From the larger asymmetrical system the cases of line-squalls and cyclones may be cited as examples. In the former, which are long asymmetrical vortices with horizontal axes, the tendency for the axis of rotation to become normal to the boundary surface is shown by the development, in places along the front, of vertical vortices associated with thunderstorms and showers. In the latter, according to the views of Bjerknes, the system is asymmetrical at first, being formed at a bend in the "polar front." Later the cyclone becomes surrounded by air of polar origin, tends towards symmetry, and dies. In this last stage it is the revolving fluid carried along in a general current as treated by Shaw. M. A. G.

747. *Relations between the Direction of Cirrus Movement at Paris and the Barometric Situation over Europe.* **L. Besson** and **H. Dutheil.** (Comptes Rendus, 173. pp. 1104–1106, Nov. 28, 1921.)—Cirrus observations for 10 years are classified according to the direction *from* which the cloud moves. Observations during the winter and summer half-year are separated, as also those occurring with surface pressure above or below 760 mm. For each class a map of mean surface pressure has been prepared together with mean isallobaric charts for intervals between 7 a.m. of the day of observation and the same hour of the previous evening as well as of the next morning. The results are briefly discussed and summarised in a table. There is a marked tendency especially with surface pressure above 760 mm. for cirrus with a west component to have a component across the surface isobars in the sense of movement from low to high pressure. For cirrus with an east component the reverse holds, though less definitely. The isallobaric charts led the authors to formulate a rule that an observer standing with his back to the direction from which the cirrus is moving has on his right an area where pressure will fall and on his left an area where pressure will rise. Further, if the cirrus has a north component (or is from S.E. in winter) the area of fall extends in front of him and the area of rise behind, while the reverse holds, with the above exception, for cirrus with a south component.
M. A. G.

748. *Low-Sun Phenomena in Luzon.* II. *Zenith Observations of Dawn, Baguio,* 1920. **W. J. Fisher.** (J. of Sci. Philippine, 17. No. 5. pp. 487–488, Nov., 1920. Popular Astron. 29. Nos. 5 and 7. pp. 1–25, May, Aug., and Sept., 1921.)—By observing the time of first appearance of blue in the zenith a lower limit has previously been obtained for the upward extent of the atmosphere. The largest value deducible from the observations was 181·6 km., which is to be contrasted with 70 km. deduced by others from horizon observations of dawn and twilight [see Abs. 1238 (1920)]. Before the "blue dawn" a pale silvery light spreads up towards the zenith, and observations of the time at which this "pale dawn" reaches the zenith should also yield a lower limit to the extent of the atmosphere. Consistent observations of this could not formerly be obtained as the effect was masked by the artificial illumination of the lower hazy air by the light of Manila. Observations have, however, now been obtained from a high-level station and give the value 211 km. as a lower limit to atmospheric extent.

III. *Marine Sunsets and the Duration of Sunset on Manila Bay and the China Sea.* **W. J. Fisher.** (J. of Sci. Philippine, 17. No. 6. pp. 607–614, Dec., 1920.)—Since refraction may be expected to act equally upon the upper and lower limbs of the sun as they respectively pass the sea horizon, the duration of sunset should be independent of refraction and calculable from Nautical Almanac data. The author has found, however, that the observed time often exceeds the theoretical by a considerable amount. The sequence of forms which the sun's disc appears to go through as it dips below the horizon has been studied, and on this basis it is found possible to classify sunsets into two types (A and B) for details of which the paper must be consulted. Type A is thought to be associated with a reversal of the normal gradient of atmospheric refractive index in the lower layers, and indeed it is often accompanied by "mirage." With this type the observed duration of sunset agrees with the theoretical. Type B, on the other hand, is thought to be associated with a strengthening of the normal gradient of refraction and is never accompanied by "mirage." In this case the observed duration exceeds the theoretical sometimes by as much as 20 or 25 secs. As the sun approaches the horizon its lower limb becomes much flattened, and the author thinks that under these circumstances the actual moment of contact is anticipated by the observer and that this accounts for the apparently excessive duration of sunset with this type. M. A. G.

749. *Relation between the Direction of Depressions and that of Maximum Wireless "Atmospherics."* **J. Lacoste.** (Comptes Rendus, 173. pp. 843–845, Nov. 7, 1921.)—Observations with the radiogoniometric installation at the Geophysical Institute, Strasbourg, during the summer of 1921, lead to the conclusion that the direction of max. atmospherics is definite in two cases: that of a distant depression when it is the direction of the S. or S.E. region of the system, and that of a near-by localised thunder-system when it is the direction of the storm. With secondary depressions or cols in the vicinity, the direction of the maximum is indeterminate and atmospherics are violent in all azimuths. Not only has the movement of depressions been followed but the first warning of the arrival of a new system has been given. The observations suggest also that fog facilitates the transmission of atmospherics. M. A. G.

750. *Elliptical Haloes.* **A. G. Cook.** (Observatory, 44. pp. 334–335, Nov., 1921.)—Emphasises the reality of oval haloes, two observations of which are mentioned in the Journal of the Leeds Astronomical Society (No. 25, p. 27). Bravais and Flammarion both held that the departure from circularity is an illusion, but the true explanation has been given by T. W. Backhouse and by L. Besson, namely, that the oval halo is the "circumscribed halo" of the circular 22° halo, formed by the joining up of the upper and lower tangent arcs (concave to the sun or moon) as the sun or moon increases in altitude. These authors, however, do not agree on the altitude at which formation of the circumscribed halo takes place. After formation and with a further increase in the sun's altitude the space between the circumscribed and the ordinary halo diminishes and they finally coincide. Observers should note how quickly this takes place. M. A. G.

751. *Mass-Grouping of Raindrops.* **W. J. Humphreys.** (Monthly Weather Rev. 49. pp. 499–500, Sept., 1921.)—It has been observed by Defant [Abs. 2020 (1905)] and confirmed by T. Okada, that the masses of the drops in any particular fall of rain tend to group themselves about values in the ratios 1 : 2 : 4 : 8 . . . . The author endeavours to explain this by assuming that near the base of the rain cloud the majority of the drops are of uniform mass *m*, just great enough to overcome the upward velocity of the rising current to which condensation is due. Now Schmidt has explained how two drops falling side by side are mutually attracted. It is then argued that since drops of equal size fall with the same speed and therefore once close together continue so for some time, they are more likely to be brought into contact by chance disturbances—eddies—and by mutual attraction than are drops of different size with a consequent unequal rate of fall. Hence at the surface the drops may be expected to be grouped round the masses *m*, 2*m*, 4*m*, etc. M. A. G.

752. *Graphical Determination of Mean Winds.* **L. Dunoyer.** (Comptes Rendus, 173. pp. 1101–1104, Nov. 28, 1921.)—Describes a graphical process, employing radially ruled paper and a special transparent scale, for the rapid addition of a number of vectors $V_1, V_2, V_3 \ldots V_n$ multiplied respectively by numerical coefficients $a_1, a_2, a_3, \ldots a_n$. The application considered is to the determination of a weighted mean of the wind at various heights for artillery purposes, where rapidity of calculation is essential. M. A. G.

753. *Falling Rain and Atmospheric Pressure.* **W. J. Humphreys.** (Monthly Weather Rev. 49. p. 500, Sept., 1921.)—A spray of water falling through a vertical pipe is known to produce an increase of pressure at the bottom—a fact which has long been utilised in some form or other in the production of blasts for smelting and other purposes. This note points out that such an effect is not to be expected in the case of falling rain. The drag on the air due to each drop falling with uniform speed is equal to the weight of the drop. In the artificial case where the water is fed in at the top of the tube this represents an addition to the pressure, but with rain it is merely equal to the original contribution of the water, as water-vapour, to the barometric pressure at the surface, and therefore is not additional. M. A. G.

754. *Evolution of Climate in North-West Europe.* **C. E. P. Brooks.** (Roy. Meteorolog. Soc., J. 47. p. 173–190; Disc., 190–194, July, 1921.)—Basing his arguments on evidence provided by a number of sciences: geology, zoology, archæology, botany: the author traces the climatic changes in North-west Europe since the last Ice-age through a number of phases which he designates as follows :—(1) the Last Great Glaciation ; Arctic climate (30,000–18,000 B.C.) : (2) the Retreat of the Glaciers ; severe continental climate (18,000–6000 B.C.) : (3) the Continental Phase ; continental climate (6000–4000 B.C.) : (4) the Maritime Phase ; warm and moist (4000–3000 B.C.) : (5) the Later Forest Phase ; warm and dry (3000–1800 B.C.) : (6) the Peat-Bog Phase ; cooler and moister (1800 B.C.–A.D. 300) : (7) the Recent Phase ; becoming drier (A.D. 300–present day). While admitting that astronomical factors, such as O. Petterson's fluctuations of "tide-generating force" have some effect in producing climatic changes, the main contention of the paper is that, during the period under review, geographical changes in the distribution of land and sea, due to changes in level of the land, particularly in Scandinavia, have been such as to produce climatic effects far greater than those of cosmical origin and sufficient to explain the climatic changes indicated in the above phases. The climatic history of North America is shown to present a general similarity to that of North-west Europe, but it is thought that the apparent relationship is largely coincidence and only very partially due to world-wide climatic changes. As regards the future, it is suggested that in North-west Europe another great Continental Phase is impending which will culminate in A.D. *x*000. M. A. G.

755. *Significance of the Tracks of Pilot-Balloons in Forecasting.* **J. Lacoste.** (Comptes Rendus, 173. pp. 997–999, Nov. 21, 1921.)—The horizontal projections of the paths of pilot-balloons during a large number of ascents have been examined in relation to synoptic charts. Five types of trajectory are recognised, and the significance of each in forecasting (for France) is pointed out. A type of special interest is that in which the trajectory curves in such a way as to indicate a progressive change of wind direction with altitude. When this change is from E. or S.E. below to S., S.W., or W. above, a depression is indicated approaching France from the S.W. (Gulf of Gascony), and if the lower winds reach 4 or 5 m./sec. thunderstorms may be expected within 24 hours in at least eight cases out of ten. In winter snow is indicated. M. A. G.

756. *Calculation of Energy of the Wind.* **M. Tenani.** (Accad. Lincei, Atti, 30. ii. pp. 367–369, Nov. 6, 1921.)—Shows that the energy communicated by the wind to a motor is proportional to the integral value of the cube of the velocity, assuming a mean value for the air density and for the efficiency of the motor at various speeds. The difficulties of calculating this integral are pointed out. These arise from turbulences, the inability of any apparatus to follow the rapid variations of velocity, and the paucity of reliable continuous anemometric records. Given such records, the integral of the cube can be found either graphically by means of specially designed paper, or statistically by applying to the cube of each velocity its frequency of occurrence. The importance of the problem in determining the probable output of a wind motor in any given locality is pointed out by the author. J. W. T. W.

757. *Calculation of Wind Energy.* **M. Tenani.** (Accad. Lincei, Atti, 30. ii. pp. 414–416, Nov. 20, 1921.)—In continuation of previous work on this subject [see preceding Abs.] the author has calculated, and gives in the form of a table, (i) the number of days of useful wind during the year 1917 at each of three stations, and (ii) the number of useful days for each month at one of these stations. A useful day is one on which the velocity of the wind exceeds 5 m./sec. The corresponding values of horse-power available per sq. metre of air-exposed surface are given in the tables, and in the particular example chosen December proves the most efficient month and June the worst. It is pointed out that the experiments should be carried out at different heights above the ground. J. W. T. W.

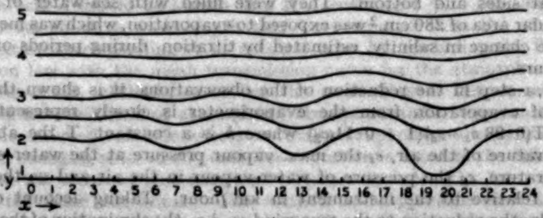
758. *Nomogram for Reduction of Barometric Pressure.* **H. G. Schwerdt** and **W. W. Loebe.** (Meteorolog. Zeits. 38. pp. 139–142, May, 1921.)—A nomogram providing a graphical solution of the equation: $\log B - \log b = gh \log e/287 \cdot 04T$, where B is the pressure at sea-level, b the pressure at height h (metres), and T the (virtual) mean temperature of a column of air from sea-level to height h. The scales bearing B, b, and T are parallel, the points representing any given pair of values of b and T being collinear with that representing the corresponding value of B. The B and T scales are the same for all values of h, but the b scale is constructed on a separate line, parallel to the others, for each value of h. M. A. G.

759. *Vapour-Pressure and Humidity Diagram.* **R. E. Horton.** (Monthly Weather Rev. 49. pp. 285–287, May, 1921.)—A nomogram constructed from the United States Weather Bureau psychrometric tables. Temperature and vapour pressure are represented on lines at right angles, the vapour pressure scale being uniform and the temperature scale so adjusted as to make the graph of temperature against max. vapour pressure a straight line through the origin. The temperature–vapour-pressure graphs for other relative humidities then form a family of straight lines through the origin. In addition, wet-bulb temperature is represented on a uniform scale along the same line as vapour pressure, and a family of curves is drawn, one member for each dry-bulb temperature, by plotting wet-bulb against dew-point temperature, the same scale being used for the latter as for temperature originally above. A simple operation then gives relative humidity, dew-point, and vapour pressure when wet- and dry-bulb readings are given. M. A. G.

760. *Pacific Earthquakes.* **G. Angenheister.** (New Zealand J. of Sci. 4. pp. 209–231, Nov., 1921.)—This paper is a study of the earthquakes whose epicentres lie near that part of the Pacific known as the Tonga Deep. For a strong earthquake (strength VIII) the true tilt did not exceed 2″ six minutes after the end of violent shaking. The times of the P. and S. waves indicate that the velocity under the ocean is 18 % greater than under the continent. Moreover, the velocity of main waves under the Pacific is from 21 to 26 % greater than under the Asiatic continent, and the absorption of energy is also greater. The time period of the Coda waves gives 41 km. for the thickness of crust under the Pacific, and 28 km. under the Asiatic continent. Finally, the properties of the upper crust deduced from its seismic behaviour are in agreement with deductions from gravity observations. W. A. R.

761. *Tide-Generating Potential.* **A. T. Doodson.** (Roy. Soc., Proc. 100. pp. 305–329, Dec. 1, 1921.)—In order to attack the problem of the difference between tide predictions and observation, a thorough development of the potential was necessary. The development given covers all the needs of research work, since it includes all terms whose coefficients (relatively to the greatest coefficient) are greater than 0·00010. Schedules of the coefficients are given. It is suggested that all constituents should be regarded as functions of local mean lunar time (as angle); the moon's mean longitude; and the sun's mean longitude, with appropriate speeds. Further, analyses and predictions should be made with variable coefficients, automatically applied; and these are to be regarded as constants only over a sufficiently short period of time. W. A. R.

762. *Sand-Dunes.* **F. M. Exner.** (Akad. Wiss. Wien, Ber. 129. 2A. Nos. 9 and 10. pp. 929–952, 1920.)—The paper is in two parts, in the first of which is advanced a theory as to the particular form of air motion associated with the formation of sand waves, while in the second their propagation is considered. The question arises as to the nature of the transition from small ripples to large dunes of much greater wave-length. Laboratory experiments, in which an artificial current of air was passed over a sand surface, produced sand waves, transverse to the current, of length increasing gradually down-wind. Mathematical investigation failed to yield a complete dynamical theory, but the air motion appears to be well represented by the stream function



$$\psi = uy + Ae^{-\beta(r-x)^{1/2}} \sin \{\beta(r+x)^{1/2}\},$$

where $r^2 = x^2 + y^2$, the x-axis being horizontal and the y-axis vertical. Of the stream lines, shown in the figure, any one may be taken as the sand surface. The wave-length increases from left to right in arithmetical progression, as was very approximately the case in the laboratory experiments. It is suggested that with sand waves on a natural scale, such a motion occurs in which the oscillations grow as the air passes farther over the yielding surface, and also that wave motion of this kind may occur at sea.

The propagation of sand waves is slow and differs essentially from that of waves in water, in that the particles of sand do not execute orbital motion. The surface particles are translated under the shearing force of the wind. Taking gravity into account, the height η of any point of the wave profile is found to satisfy the approximate differential equation $\partial\eta/\partial t = -k\,.\,\partial\eta/dx + m\,.\,\partial^2\eta/\partial x^2$, where the first term on the right is due entirely to the effect of wind. An integral is $\eta = Ae^{\gamma x - \mu t} \sin(\delta x - \epsilon t)$, where $\mu = k\gamma - m(\gamma^2 - \delta^2)$, $\epsilon = \delta(k - 2m\gamma)$, corresponding to an initial profile $\eta = Ae^{\gamma x} \sin \delta x$. This is discussed in detail, it being shown that, according to the value of γ, waves may be propagated up- or down-wind, may increase or decrease in height and that the speed of propagation is not in general independent of the wave-length. Differences in this speed are capable of explaining the formation of the crescent-shaped dunes commonly observed, with points either up- or down-wind, from straight dunes which are not uniform along their whole length.

M. A. G.

763. *Evaporation from the Sea.* **G. Wüst.** (Inst. f. Meereskunde, Verhandl. [Neue Folge, geogr.-naturw. Reihe], No. 6. Berlin, Oct., 1920. Meteorolog. Zeits. 38. pp. 188–190, June, 1921.—Abstract.)—*Evaporation.*—Employing data consisting of measurements of evaporation by means of evaporimeters of uniform type, carried on ships during several long cruises in the northern and southern hemispheres, the author endeavours to estimate the zonal distribution of evaporation from the oceans. The instruments used were supported so as to swing freely independently of the ship's motion, exposed to sun and wind, but shielded from radiation at sides and bottom. They were filled with sea-water of which a circular area of 280 $\mathrm{cm.}^2$ was exposed to evaporation, which was measured by the change in salinity, estimated by titration, during periods of 12 or 24 hours.

As a step in the reduction of the observations, it is shown that the rate of evaporation from the evaporimeter is closely represented by $v = k\mathrm{T}(0\cdot98\, e_s - e_d)(1 + 0\cdot11 w_2)$ where k is a constant, T the absolute temperature of the air, e_s the max. vapour pressure at the water surface temperature, e_d the pressure of water-vapour in the air and w_2 the wind speed relative to the instrument in km./hour. Taking account of this formula, the reduction to the true wind w_1, i.e., the elimination of the ship's motion, is effected by multiplying by the factor $(1 + 0\cdot11\, w_1)/(1 + 0\cdot11 w_2)$. The conditions under which evaporation takes place at the evaporimeter on board and from an element of the sea surface differ considerably, and further reduction by a factor of the order 0·5 is found necessary. The final result, given as an estimate of the average daily evaporation from 10° zones (account having been taken of the departure of the meteorological conditions at the time of the observations from average conditions), is :—

Zone	80° N.	70°.	60°.	50°.	40°.	30°.	20°.	10°.	0°.	10°.	20°.	30°.	40°.	50°.	60°.	70° S.	
Atlantic Ocean..	0·2	0·3	1·0	1·8	2·5	3·2	3·4	2·5	3·3	3·2	2·9	2·3	1·5	0·6	0·2		mm./day
All oceans	0·2	0·3	1·0	1·8	2·5	3·0	3·1	2·6	2·9	3·1	2·9	2·3	1·5	0·6	0·2		mm./day

Relation between Evaporation, Precipitation, and Surface Salinity.—A further investigation into the difference between evaporation V and precipitation N for the Atlantic Ocean shows that the former is in excess between latitudes 40° N. and S., except near the equator, and that outside these limits precipitation predominates. The difference is related to the surface salinity S by the expression

$$\mathrm{S}\ (\text{‰}) = 35\cdot74 + 0\cdot0126\ (\mathrm{V} - \mathrm{N}).$$

M. A. G.

764. *Newtonian Physics and the Displacement of Spectral Lines towards the Red.* **S. Mohorovičić.** (Ann. d. Physik, 66. 3. pp. 227–228, Dec. 6, 1921.)—The displacement of spectral lines towards the red can be derived from Newtonian physics if the light is treated as a stream of particles possessing mass [see Abs. 1538 (1921)]. A simple mathematical treatment here given leads to Einstein's formula for the displacement towards the red of light subjected to the gravitational field of the sun or similar body. **A. W.**

765. *Gravitational Displacement of the Fraunhofer Lines.* **L. C. Glaser.** (Phys. Zeits. 23. pp. 100–102, Feb. 15, 1922.) **L. Grebe.** (p. 102.)—Glaser here criticises the work and conclusions arrived at by Grebe and given in a previous paper [Abs. 381 (1921)]. Grebe replies that he considers Glaser's objections are all wrong. **A. W.**

766. *The Wave-Length in Astronomical Interferometer Measurements.* **J. A. Anderson.** (Mt. Wilson Observat. Contrib. No. 222. Astrophys. J. 55. pp. 48–70, Jan., 1922.)—*Effective Wave-Length in Measurements.*—The separation of double stars and the diameters of stellar discs are measured by the interferometer in terms of an effective wave-length λ which is such that if the stellar object emitted monochromatic light of wave-length λ the setting of the interferometer would be that actually found. The accuracy of setting obtainable in these measurements is such that in each case λ should be known to a few tenths of 1 %. *For any star,* the normal effective wave-length may be computed from the effective temperature corresponding to its spectral type by combining the Planck radiation law with the mean transmission curve for the atmosphere and with the A.I.S. visibility-curve for the normal eye. The corrections required for variations of atmospheric absorption and of eye sensitivity from the assumed values may best be obtained experimentally by observations on sunlight, since in any case the correction is equal to the difference between the observed and computed effective wave-lengths for sunlight under the same conditions. The method and apparatus used in the *determination of the effective wave-length for sunlight* are described, and the results of some observations on the *variation of λ with zenith distance and atmospheric conditions* are given. On Mount Wilson the values found vary from 5660 Å. at sunrise and sunset to 5510 Å. for zenith distances up to 60°; at Pasadena the variation with zenith angle was more rapid. The wave-length was greater on cloudy days and least after a rain.

Astronomical Interferometer.—The distribution of intensity in the interference patterns, for both circular and rectangular apertures, is fully discussed, and in the particular case of a double star is given mathematically for all points of the focal plane, for all orientations of the apertures. *The effect of the size of the apertures on the setting* is nil when rotation is used and also when the setting is made for minimum visibility of the fringes; but when the apertures are separated until minimum intensity at the centre is obtained, it is found both theoretically and experimentally that for apertures of width a and separation D, the effective separation is very closely equal to $D/[1 + K(a/D)^2]$ for D/a greater than 3·5, where K is 0·223 instead of 0·765 as given by Hamy. AUTHOR.

767. *Investigation of the Constancy in Wave-Length of Atmospheric and Solar Lines.* **C. E. St. John** and **H. D. Babcock.** (Mt. Wilson Observat. Contrib. No. 223. Astrophys. J. 55. pp. 36–47, Jan., 1922.)—In 1915 Perot reported having found the wave-length of an O line considerably longer at noon than at sunrise and sunset. Since these lines are constantly used as standards of wave-length in solar observations, a study of the *wave-length as a function of the altitude of the sun* was made for a number of atmospheric lines in the B group at λ6867, in the *a* group at λ6276, and in the water-vapour band near λ5900. Measurements of 25 plates show no indication of a variation greater than the accidental error. Moreover, spectrograms and data accumulated at Mount Wilson since 1911 give wave-lengths, some determined with reference to solar lines and some with reference to arc lines, which agree very closely, the difference from the general mean shown by any plate seldom exceeding 0·001 Å. This negative result indicates the absence of high velocity *radial currents in the earth's atmosphere*, and justifies the use of atmospheric lines as a reliable standard of reference even in work requiring the highest precision.

Constancy in Wave-Length of Lines from the Centre of the Solar Disc.—While Evershed reported in 1919 remarkable variations amounting to several thousandths of an Ångstrom, the experience at Mount Wilson is that the more carefully the solar wave-lengths are compared with standard arc lines, the smaller the deviations from spectrogram to spectrogram become. Evidence from 13 plates is presented. These results prove that the *radial convection currents in the sun*, while not absent, are remarkably constant: at high levels they are apparently downward; at low levels, upward but small. AUTHORS.

768. *The Ultra-Violet End of the Solar Spectrum.* **C. Fabry** and **H. Buisson.** (Astrophys. J. 54. pp. 297–322, Dec., 1921.)—*Solar Spectrum from λ3150 to λ2900 Å.*—To obtain photographs of this region it is necessary to eliminate diffuse light of longer wave-length. This was done by using a *double spectrograph*, consisting of two quartz spectrographs in series arranged with their dispersion planes at right angles. The intensity of the spectrum falls off very rapidly, being only one-millionth as great at λ2900 as at λ3150; therefore, to enable the whole region to be photographed at once for measurements of absorption, *two absorption screens* made by intensifying photographic films with $HgCl_2$ were used in echelon to reduce the intensity above λ2990. To obtain a *photographic map* with uniform normal exposure throughout, two plates, each covering half the region, were exposed by moving a shutter by hand at proper predetermined rates across each spectrum. The wave-lengths will be published soon.

Absorption of the Atmosphere for λ3150 to λ2900 Å.—By comparing the intensities of spectrograms taken for various zenith angles, the *coefficients* for various wave-lengths were determined. The effect of molecular diffusion was corrected for by using the Rayleigh formula, and the effect of haze was eliminated by assuming it independent of wave-length. A comparison with the corresponding coefficients for ozone, previously determined by the authors, shows remarkable agreement, leaving no doubt that this absorption is due to ozone.

Ozone in the atmosphere is found to be equivalent to a layer about 3 mm. thick at atmospheric pressure. The *daily values* for May and June 1920, vary irregularly from 0·29 to 0·34 cm. It would be interesting to follow these *variations* through a solar period. It is shown that the *location of this ozone* must be in the outer layers of the atmosphere, above 40 km., and in *explanation of its origin* it is suggested that the ozone is produced by solar rays of wave-length shorter than λ2000 which penetrate only the outer layers, and that longer rays dissociate the ozone and prevent its accumulation beyond the amount for equilibrium.

Distribution of energy in the solar spectrum outside our atmosphere for

λ3150 *to* λ2900 Å. was determined by correcting the observed intensities for the absorption by the atmosphere and then reducing to units of energy by the use of a calibration-curve obtained by comparing the intensity-curve of an arc with the radiation from a black body at 3750° abs. The energy-curve thus obtained shows only a gradual slope toward the shorter wave-lengths. For $\lambda\lambda$3143, 2997, 2922, and 2898 the relative energies for the sun outside the earth's atmosphere come out 155,000, 218,000, 145,000, and 45,000 respectively, while at the surface of the earth when the sun is at the zenith the corresponding values are about 22,400, 1320, 2·2, and 0·02. AUTHORS.

769. *Note on Cooling by Expansion in Sun-spots.* **H. N. Russell.** (Mt. Wilson Observat. Contrib. No. 217. Astrophys. J. 54. pp. 293–295, Nov., 1921.)—Assuming the low temperature of sun-spots to be due to the expansion of the rapidly rising gases, it is shown that the base of the spot vortex must be a region of very high temperature, probably over 20,000°, and the increase of volume on ascending must be large, probably over 30 times. Only rough estimates can, however, be made. AUTHOR.

770. *Cubic Shapes of Certain Ions, as Confirmed by X-Ray Crystal Analysis.* **W. P. Davey.** (Phys. Rev. 17. pp. 402–403, March, 1921.)—A study has been made of the crystal structure of compounds formed by equal numbers of each of two oppositely-charged ions which are cubic according to the theory of Lewis, Born and Landé, and Langmuir. New data added to that at present available in the literature allow this study to cover ions whose atomic numbers range from 8 to 82. The results of these purely physical experiments contribute towards an experimental verification of the theory of atomic shapes, which was originally devised to explain the chemical properties of the elements. L. H. W.

771. *Crystal Structure of Two Rare Halogen Salts* (*CsCl and TlCl*). **W. P. Davey** and **[Miss] F. G. Wick.** (Phys. Rev. 17. pp. 403–404, March, 1921.)—The crystal structures of CsCl and TlCl have been studied by the powder method of Hull. CsCl gives a diffraction pattern of a simple cube of side 4·12 Å. The density of the elementary cube shows that one CsCl group is associated with each point of the cubic lattice. CsCl is therefore to be thought of as a simple cube of Cs ions with a Cl ion at the centre of each cube. This structure is different from that assumed by Bragg from crystallographic data, and the distance observed between Cs and Cl atoms cannot be calculated from the atomic dimensions assumed by Bragg. TlCl gives a diffraction pattern identical with that of CsCl, except that the side of the elementary cube is 3·85 Å. Its density shows an atomic arrangement identical with CsCl. The atomic distances are not consistent with Bragg's volume of thallium. AUTHOR.

772. *Absolute Sizes of Certain Monovalent Ions.* **W. P. Davey.** (Phys. Rev. 18. pp. 102–104, Aug., 1921.)—Most of the structures and dimensions of crystals here tabulated have been dealt with previously [see two preceding Abs.]. The sizes of the ions have been recalculated, using only assumptions dealing with ions, rather than atoms, thus avoiding the objection to Bragg's calculations, namely, that the atoms of metals are considerably larger than their corresponding ions. The crystals dealt with are: NaF, NaBr, NaI, KBr, KI, CsCl. L. H. W.

773. *Crystal Structures of Alkali Halides.* **R. W. G. Wyckoff.** (Washington Acad. Sci., J. 11. pp. 429–434, Nov. 4, 1921.)—The author calculates the crystalline structure of the halides of sodium, potassium, rubidium, and caesium from X-ray "powder" photographs. Sodium chloride was taken as a standard, the length of the cell being taken as $5{\cdot}628 \times 10^{-8}$ cm. The following results are tabulated :—

Substance.	Calculated Density.	Spacing, d_{100} (Å.U.).	Structure.
NaBr	3·20	5·95 ± 0·01	NaCl grouping
NaI	3·62	6·47 ± 0·01	,,
KCl	—	6·26 *	,,
KBr	2·73	6·59 ± 0·02	,,
KI	3·03	7·11 ± 0·02	,,
RuCl	2·76	6·60 ± 0·02	,,
RuBr	—	6·93 †	,,
RuI	3·49	7·36 ± 0·02	,,
CsCl	—	4·12 ‡	Body-centred
CsBr	4·39	4·30 ± 0·01	,,
CoI	4·54	4·55 ± 0·015	,,

* W. H. Bragg and W. L. Bragg.

† W. P. Davey [Abs. 772 (1922)].

‡ W. P. Davey and F. G. Wick [Abs. 771 (1922)].

Further results are promised in a subsequent paper. A. B. W.

774. *Tendency of Long Bodies to Set N. and S.* **A. Schuster.** (Nature, 108. p. 240, Oct. 20, 1921.)—Referring to the exhibit by A. E. Reeves at a Royal Society soirée, 1920, in which a charged film in a jar sets N. and S., the author shows that an elongated body tends with a very weak force to set in this way on account of the earth's rotation, the centrifugal force on the rod being greater at the southern than at the northern end. Suppose the rod of mass σ per unit length is hung by a fine fibre, and deflected a small angle ϕ; if the earth's angular velocity be ω, and the co-latitude at the place be θ, the couple acting to restore the rod to the meridian is $\int \sigma\omega^2 s \cos^2\theta \sin\phi \cos\phi \, ds = I\omega^2 \cos^2\theta \sin\phi \cos\phi$, where s is the distance of any point in the rod from its centre, and I the moment of inertia of the rod. The vibrations are determined by $I \, . \, d^2\phi/dt^2 = I\omega^2 \cos^2\theta \, . \, \phi$, and the period of an oscillation, which is independent of I, is $T \sec\theta$, where T is the period of the earth's revolution. Thus the time of one oscillation is that of the time of a complete revolution of Foucault's pendulum, which in our latitude is about 31 hours. A numerical example is worked out. P. E. S.

775. *Tendency of Elongated Bodies to Set E. and W.* **W. D. Lambert.** (Nature, 108. p. 528, Dec. 22, 1921.)—Schuster's theoretical results show that elongated bodies, if free, tend to point N. and S., but a complete calculation, according to Lambert, shows that the tendency is for a setting to be E. and W., the missing element in the former calculations being the difference in the direction of the centrifugal force on the different portion of the elongated rod. Also there must be considered not only the changes in amount and direction of centrifugal force, but also the changes in gravity due to the departure of the earth from sphericity. Lambert considers the theory of the Eötvös balance in connection with this subject.

P. E. S.

776. *Tendency of Elongated Bodies to Set North.* **E. A. Reeves.** (Nature, 108. p. 433, Dec. 1, 1921.)—In reply to E. H. Grove-Hills (*ibid.*, p. 403, Nov. 24, 1921) and A. Schuster and W. D. Lambert [see two preceding Abstracts], Reeves states that decisive setting has been found with circular rings and discs only 3½ cm. in diam. of the lightest paper. When the sky is clear, the barometer high and steady, no wind, and the apparatus set on high, level ground in the open, the disc may come to rest in as little as five minutes, or oscillate a few degrees each side of true N. Similar results have been found with discs and pointers floating on paraffin. In cloudy weather the pointing is towards the most dense cloud. Similar results have now been found in different parts of the world, from Spitzbergen to the equator. P. E. S.

777. *The Directive Tendency of Elongated Bodies.* **W. D. Lambert.** (Nature, 109. pp. 271–272, March 2, 1922.)—There are two kinds of forces acting on a floating body, viz., the force due to the earth's gravity field, which is a body force, and the normal pressure of the fluid on a wetted surface. The author considers the turning effect on a floating body due to the earth's field and the fluid pressure jointly. He next considers the tendency of continental masses, which may be taken as analogous to floating bodies, to move towards the equator on account of the earth's rotation; also the case of the movement of icebergs towards the equator due to the same cause. P. E. S.

778. *Atmospheric Refraction.* **J. de G. Hunter and A. Mallock.** (Nature, 107. p. 745, Aug. 11, 1921.)—The author objects to a letter by Mallock on this subject [see Abs. 1735 (1921)], in which he considers that an improbably high value is postulated for the coefficient of atmospheric refraction, 0·133, as against ordnance survey values of 0·0809 over sea and 0·0750 over land. He also appeals to Indian survey experience in opposition to some other points in the letter. He refers to the diurnal variation of refraction, due to changes of temperature in the lowest 300 ft. of the atmosphere, and to the special anomalous cases found when the path of a ray is mostly within that low layer. Mallock replies that the approximate assumptions made must be governed by the order of accuracy aimed at, and that the modification due to temperature, for instance, is too small and uncertain to be worth much notice, especially in the presence of an unknown quantity of water-vapour, which would have a similar effect. He also traverses some of the general statements that conduction is responsible for the irregularities in the lowest layer.

W. W. B.

779. *A Special Case of Diffraction of Images of Circular Celestial Objects, and Measurement of their Diameters.* **M. Hamy.** (Comptes Rendus, 173. pp. 888–892, Nov. 14, 1921.)—In continuation of previous work [see Abs. 73 (1922)], the author proceeds to consider the case when the brightness of the object is not uniform, and also tries to find some method of eliminating the physiological error, which replaces the geometrical limb by an optical one. Having found the best value for the parametric n^2/m (*loc. cit.*) to be $\frac{1}{2}$, he has studied the relative intensity for this value, varying the eyepiece magnification, but using a calculated screen with the lower power, to ensure equal brightness of image. Then assuming that the difference between the optical and geometrical limbs is proportional to the magnification, he claims that he can determine the geometrical diameter and the difference in each case between the optical and geometrical limb. The method does not seem to apply to small planets, and for the sun special considerations are involved, depending on the falling off in brightness towards the limb. For this he suggests glacier stations, to avoid the interference of convection currents, but postpones further discussion until he has completed some work now in hand. W. W. B.

780. *Method of Synchronisation of Clockwork of Equatorial Telescopes.* **d'Azambuja.** (Comptes Rendus, 173. pp. 494–497, Sept. 19, 1921.)—In general the equatorial driving of a telescope is less regular than that of an astronomical clock, and this the author considers more important than the other defects (imperfect adjustment of axis, flexure, refraction, etc.), which compel the observer to guide the telescope during long-exposure photography. He considers the ideal method of overcoming this difficulty to be the replacement of the old weight-driven clock and its regulator by a magneto, put into action by contacts made by the pendulum of the astronomical clock. This device is not yet available at Meudon, and the author describes the arrangement actually in use there for two cœlostats which feed solar spectroheliographs. The weight-driven electric motor of the cœlostats has an axis turning once in a second, which is connected with an axis in the pendulum clock turning three times in a second. The regulator is arranged to gain slightly on the pendulum, the limits being $\frac{1}{200}$ and $\frac{1}{2000}$, or between 1·8 sec. and 12 secs. per hour. A circuit is provided, fed by a single-cell battery; with two gaps, closed respectively by the pendulum and the regulator. The current only passes when the difference of rate has produced synchronisation of the two contacts. When this occurs a spur-wheel is allowed to slip one tooth and thus retard the regulator by an amount greater than the difference of the two speeds, so that the next revolution will not make the two contacts, but only one in two, or one in three.

The range of control is wide enough to allow for the difference between mean solar and sidereal time, so that very satisfactory synchronisation can be obtained for stellar or solar photography, according to which pendulum clock is put in circuit. W. W. B.

781. *The Scale of the Universe.* **H. Shapley and H. D. Curtis.** (Nat. Research Council, Bull. 2. pp. 171–217, May, 1921.)—The authors maintain, in turn, the two conflicting hypotheses as to the scale of the universe, each having had access to the other's arguments, so that the whole should represent fairly every argument for or against the two theories. In the first part Shapley supports his recent suggestion of a diameter of something like 300,000 light-years for the galaxy, at least 10 times larger than the estimates of, say, ten years ago. He claims that several of the authorities responsible for the smaller values of the galactic dimensions have since enlarged their ideas, notably Kapteyn, and he thinks that even Curtis has modified some of his ideas, and is in much closer general agreement with him than is commonly supposed. He considers his case proved as against Curtis if it can be shown that the distance of any bright globular cluster is roughly as below, in light-years: M13, 36,000; M3, 45,000; M5, 38,000; or ω Centauri, 21,000: or that the bright stars in clusters are giants. If his distances have to be reduced to one-tenth of his figures, he considers that Russell's theory of spectral evolution and Eddington's theory of gaseous giant stars must be greatly modified, if not given up; although they receive powerful support from their simplicity and their success in fitting the facts of observation. A serious blow would also be struck against the period-luminosity law of Cepheid variation, and generally against any spectroscopic determination of star distances. Summing up his case for the M13 cluster at 36,000 light-years distances, he deduces greater distances for the fainter, smaller globular clusters, and deduces a diameter for the whole system of 300,000 light-years.

In the second part Curtis draws attention to the small number of distinct main classes of objects in the galaxy. (1) Stars, velocity 10 to 30 km./sec.; (2) globular clusters, velocity of the order of 300 km./sec. (3) Diffuse nebulæ, velocity very low. (4) Planetary nebulæ, velocity about 80 km./sec. (5) Spirals, velocity of the order of 1200 km./sec. Of these (2), (3), and (4) are galactic in distribution, and (5) emphatically not. This suggests that the spirals are a class apart, "island universes," external to and comparable with our galaxy. If of similar dimensions, their distances range from half a million to ten million or more light-years. He quotes Schouten's table to show how small a proportion of the stars in any region are giants. He examines in detail the principles upon which the vast distances of the globular clusters, on which Shapley's argument depends, have been derived. Three lines of evidence are: (1) Determination of relative distance of clusters on the assumption that they are objects of the same order of actual size. This seems rather risky, as a threefold, or even fivefold, difference would be considered to be included in the same order of size, but hardly of distance. (2) Determination of absolute distances of clusters through correlations between Cepheid variables in the clusters and in our galaxy. This is Shapley's favoured method, and depends on an assumed close resemblance between the characteristics of all Cepheids, whether in clusters or not, and the coordination of absolute magnitude and length of period, from which the absolute scale is derived depends almost entirely upon the sizes and internal relationships of eleven Cepheids only. The proper motions of these are affected with probable errors of nearly the same magnitude as the proper motions, so these data are very uncertain. Curtis shows how badly some other Cepheids fit the curve derived from the eleven thus used, for the luminosity-period correlation. He therefore would prefer that this weapon should be laid aside until a larger quantity of data, giving more consistent results, is available. As regards the distance determined for any cluster, he quotes those for M13, made in recent years, ranging from 170 light-years to Shapley's provisional 100,000, reduced to 36,000, and considers that a reasonable value would be 8000.

He then turns to the question of the spirals being external galaxies, and gives in parallel columns the deductions as to size, spectrum, distribution, and space-velocity, according as they are regarded as belonging to the galaxy of the larger dimensions, or as external and similar to the galaxy of smaller dimensions. On the question of novæ in spirals, he quotes Shapley's simple hypothesis that they represent the running down of ordinary galactic stars by rapidly moving nebulosity. To test this, he counts the stars in a number of areas about the Andromeda nebula, finding a star-density of 6000 per square degree. Taking Shapley's distance of 20,000 light-years, and velocity 300 km./sec., he deduces a collision every 520 years, but 16 novæ have appeared in the nebula in the last few years; hence the star density would appear to be about 2000 times as great as in the count. He finally sums up the points in favour of the spirals being island universes. On these grounds he thinks the smaller value of galactic dimensions, diameter about 30,000 light-years, and thickness about 6000 light-years, as more probable than the tenfold greater values, but is not inclined to dogmatise, as he feels that the whole subject is full of assumptions and uncertainties. W. W. B.

782. *Path of a Ray of Light in Einstein Relativity Theory of Gravitational Effect.* **A. R. Forsyth.** (Roy. Astron. Soc., M.N. 82, pp. 2–11, Nov., 1921.)—Starting with the accurate equation of the path, which he finds everywhere concave to the sun, the author obtains the coordinate velocity in the path, the general value of the defraction of a ray passing from a star to the earth, and the approximate expression for the deflection. He considers that the accuracy obtainable is one in a thousand millions. If greater accuracy is desired, neglected square terms must be considered, and the whole process revised. He gives finally the approximate equation of the path, with resulting deviation $1/r - 1/r_1 = (m/D^2)(1 - D/r_1)(2 + D/r_1)$, where D is perihelion distance. W. W. B.

783. *Distribution of Brightness in Penumbra during a Lunar Eclipse.* **F. J. W. Whipple.** (Nature, 108, pp. 497–498, Dec. 15, 1921.)—Reported observations of the edge of the umbra during the lunar eclipse of Oct. 16, suggested to the author that the sharp boundary often assigned to the umbra cannot be correct, as the fading off must be gradual. He therefore computed the geometrical decrease of illumination, giving the distribution of light in the shadow. He suggests the importance of determining the proportion of sunlight that reaches the eclipsed moon through the earth's atmosphere, and mentions the cognate problem of the brightness of the earthshine on the new moon. W. W. B.

784. *Law of Rotation of the Sun.* **H. F. Newall.** (Roy. Astron. Soc., M.N. 82, pp. 101–114, Dec., 1921.)—The author gives a detailed examination of the solar theory of Faye, in the light of modern spectroscopic determinations of local velocities in different parts of the sun. In the ordinarily accepted spectroscopic formula for the corrected velocity, $(a - b \sin^2 \phi) \cos \phi$, a and b have been regarded as constant for different latitudes, a being roughly the equatorial velocity, and b that which produces the variation in different latitudes. He finds that both a and b are variable, and obtains limiting values for them. The variation appears to follow the phase of the sun-spot period, and the latitude 40° seems to be indicated as critical in the relationship between a and b. The values suggest such an increase of turbulence at this region shortly after sun-spot minimum as will produce sun-spot disturbances near that latitude, which will increase and approach the solar equator as the phase of the period advances. The limiting values for *a* are found to be 2·15 and 1·85 km./sec., while *b* ranges between 0·3 and 0·8 km./sec. There is evidence that when the spots have died out near the equator the equatorial velocity increases. The author discusses the kinematic viscosity of the vapours near the reversing layer, and finds that the generally accepted view of pressure diminishing outwards, as in a gravitational field, leads to impossible increases in the viscosity.

Recent spectroscopic observations of velocity, though at present not completely available for the war years, have been, the author considers, grouped in an incorrect manner, because of the assumption of constant values for *a* and *b*. Grouping them with due regard for the sun-spot phase, he finds a fairly plausible scheme, with separate treatment above and below the critical latitude 40°. In a further discussion of the dark filamentous flocculi, no definite conclusion is reached, but there seems a possibility that they show a conflict between the general magnetic field of the sun and the local fields of sun-spots, with the further possibility that a sun-spot region may not become magnetic until one of these filaments is drawn into it. The dark filaments may serve to indicate circulation in the higher regions of the solar envelopes. W. W. B.

785. *Proposed New Method of Spectroscopic Observations of Solar Rotation.* **H. F. Newall.** (Roy. Astron. Soc., M.N. 82. pp. 115–116, Dec., 1921.)—If a *distant* sphere is rotating as a rigid body, a straight line parallel to the projected rotation axis will represent a small circle, in which the line of sight motion of any point is the same for any given inclination of the axis to the line of sight, provided the distance is great enough to allow the *variation* in this inclination to be neglected. An equidistant chord on the other side of the projected axis will mean another small circle, where the velocities are the same, but of opposite sign. The sun, however, is not a rigid body, so that there will be differences of velocity over the small circles. The author's suggestion is to accumulate observations of this difference at definite latitudes, taken simultaneously at points on both circles by means of reflecting prisms, with allowance made in the calculations for the variation of the sun's apparent diameter through the year. This method should show up local disturbances at points of observation with much more definiteness than those made close to the sun's limb. W. W. B.

786. *Systematic Corrections to Calama Solar-Constant Values.* **C. G. Abbot.** (Monthly Weather Rev. 49. pp. 458–460, Aug., 1921.)—The closing of the station at Calama, Chile, on July 26, 1920, suggests the examination, for systematic error, of the solar-constant determinations made there during the three years that observations were made at Calama, which have been published as received. The range of atmospheric humidity at Calama is nearly as great as at Mt. Wilson, where a secondary correction was deduced to allow for this, but no certain correlation emerges from the Calama observations, so no correction has been applied to the fundamental long-method determinations. The empirical short-method determinations depend for their accuracy on the curves connecting the values of the atmospheric humidity with the transmission coefficients.

These are well determined for some regions, but not for hazy skies under moist conditions, when long-method values are hardly ever obtained.

Accordingly the short-method values have been specially examined. They are computed by the aid of three sets of curves, corresponding to air masses of 3, 2, and 1½ respectively, and each set of determinations has also been classified according to high or low values of the humidity, etc. A representative set well distributed through the year should show very little fluctuation for any small range of function value, and it was assumed that for the 13 months July 1919 to July 1920 inclusive the mean values of the groups should be taken as identical with the mean value of the solar-constant long-method determinations, found to be 1·951 cal. per cm.^{2} per minute. The corrections found have been minimised, and the observations are now tabulated as observed and as corrected in accordance with the result of the investigation. The new station at Montezuma has not been in occupation long enough to determine whether any similar correction will be required there. W. W. B.

787. *Motion of Perihelion of Mercury.* **W. M. Smart.** (Roy. Astron. Soc., M.N. 82. pp. 2–19, Nov., 1921.)—Le Verrier computed that to account for the motion of Mercury's perihelion, an inner planet would require a considerable mass, and would probably have been discovered, had it existed. The author computes the requisite mass for a "Trojan Vulcan," i.e., a planet making an equilateral triangle with the sun and Mercury, and finds it ⅓ of the mass of Mercury. With limiting probable assumptions as to albedo, he deduces a mean stellar magnitude between 0·0 and 1·2. Previous searches during eclipses have been for a planet well within the orbit of Mercury, and so may not have swept far enough out from the sun to catch one which on the present hypothesis might be 23° away from the sun. The planet has not been seen crossing the sun's disc. The conclusion is that the required theoretical planet is too large to have escaped notice. Had a very small mass been sufficient, it would probably have escaped observation, but as it is, it probably has no existence. W. W. B.

788. *Recent Observation of Jupiter.* **F. Sargent.** (Observatory, 44. No. 568. pp. 269–275, Sept., 1921.)—[See Abs. 1716 (1921).] The author gives an account of the changes that have been noted in the position and apparent motion of the Great South Tropical Disturbance since its first appearance in 1901, and the anomalies attending its occasional conjunctions with the Red Spot Hollow, in particular the last conjunction beginning in February 1917. In Feb. 1919 the South Tropical Disturbance began to fade, and by the end of March became invisible in the telescope, the South Equatorial Belt and the Red Spot Hollow also fading out, though the Red Spot itself remained faintly visible. These features reappeared early in 1920. During these changes, however, the Red Spot Hollow showed changes in its rotation velocity, at one period having a quicker motion than any previously computed. These changes are tabulated for nine periods, from Oct. 1916 to March 1921.

Inferences are drawn from the phenomena. The Red Spot is clearly not a fixture, and may possibly be a nascent satellite. The disturbance moving with a velocity different to that of the parallel of Jovian latitude, n which it appears, may be explained by an upheaval, volcanic or otherwise, from the next zone of latitude, whose inertia would for some time prevent it from conforming to the velocity of the neighbouring zone, over which it had been projected. The author draws an analogy from ice floating in a river. He refers briefly to other features of the planetary surface, including dark elongated spots, "barges" in the N. Tropical Zone in the summer of 1917, and bright spots in profile on the limb in Jan. 1920, and mentions some of the regions that can be kept under close observation in small telescopes. W. W. B.

789. *Markings on Jupiter.* **W. F. Denning.** (Nature, 108. p. 547, Dec. 22, 1921.)—Commenting on observations by F. Sargent [see preceding Abs.], the author derives the length of the S. Temperate Disturbance as 149°, and its rotation period 9h. 55m. 30s. That of the Red Spot Hollow between May and December was 9h. 55m. 37·8s. This has undergone many changes since Schwabe first drew it in Sept. 1831. The Great Red Spot itself became conspicuous in 1873. W. W. B.

790. *The Third Satellite of Jupiter.* **T. E. R. Phillips.** (Roy. Astron. Soc., M.N. 82. pp. 96–100, Dec., 1921.)—The satellite Ganymede sometimes appears elliptical, and the author has taken special observations of the position angle and the amount of ellipticity, and as a result concludes that the periods of revolution and rotation are closely similar, and probably exactly equal. He accounts for the elliptical appearance not by the shape of the satellite, which is probably nearly spherical, but by a dark marking, which he has occasionally observed. W. W. B.

791. *New Formulæ for Line of Search for a Minor Planet.* **L. Fabry.** (Comptes Rendus, 173. pp. 892–894, Nov. 14, 1921.)—Perturbations by Jupiter and Saturn frequently displace minor planets, sometimes by several degrees from their predicted places. It is, however, chiefly the longitude that is affected; and they are rarely displaced so much as a quarter of a degree from the "line of search"; indicated by the ratio of the change in declination to that in right ascension. Lagrula has one method of overcoming the difficulty, and the author gives formulæ for another, which he himself uses. He urges, however, that those who compute the ephemerides should include the direction of the line of search, which will involve very little additional calculation. W. W. B.

792. *An Asteroid with a Cometary Orbit.* **Gonnessiat** and **Renaux.** (Comptes Rendus, 173. p. 895, Nov. 14, 1921.)—On 1920 Oct. 31, M. Baade at Babelsberg discovered a minor planet of 13th magnitude (1920 HZ), with an orbit of great eccentricity like that of a comet. The authors have computed elements, and find the aphelion at about the distance of Saturn. This is so interesting both from the point of view of Celestial Mechanics and of Cosmogony that special ephemerides will be computed in the hope of recovering the planet at its next opposition. It will then be of only 16th magnitude, requiring very good equipment to secure photographs. The next perihelion passage will not take place for 13 years. W. W. B.

793. *The Saturn Family of Minor Planets.* **E. Belot.** (Comptes Rendus, 173. pp. 1069–1072, Nov. 28, 1921.)—The discovery of a small planet with a very eccentric orbit like that of a comet [see preceding Abs.] provides the author with fresh justification for a theory announced in his Essay on Cosmogony in 1911, that every large planet will be followed by a train of small planets in the direction of the boundary of its envelope, in accordance with his theory of dual cosmogony [see Abs. 385 (1921) and previous papers]. He claims that 1920 HZ is to be assigned to a Saturn family of minor planets. He maintains that the spiral nebulæ are rotating in the direction of increasing *radii vectores*, and not, as is generally assumed, in the opposite direction. Thus he finds similarity in the evolution of minor planets and of spirals. The Mars family includes Eros, Adalberta, and Hungaria, while numerous members of a Jupiter family are known. W. W. B.

794. *Minor Planets.* **E. Noteboom.** (Astron. Nachr. No. 5122. Nature, 108. p. 256, Oct. 20, 1921.—Abstract.)—With the intention of correcting the value of the earth's mass, Witt's work on Eros has been continued by E. Noteboom. Eleven oppositions, 1893 to 1914, are considered, and the almost negligible actions of Mercury, Uranus, and Neptune, included for completeness. After correcting the earth's mass, no error in any of the oppositions exceeds $4''$, most of them being under $2''$. The combined mass of the earth-moon system comes out at $1/(328370 \pm 102)$, and the deduced solar parallax is $8''\cdot 799$. Eros should be observed fully at every opposition. K. Schutte investigates the orbit of (887) Alinda, discovered in 1917 by Max Wolf. Its perihelion is near the earth's orbit, but its path is eccentric, and its period of 4 years is about one-third that of Jupiter, so that it is liable to large perturbations by that planet. It is very faint, however, and so may escape re-discovery, though its observation is eminently desirable. A search ephemeris is given, as well as a continuation of the ephemeris of Eros. W. W. B.

795. *Critical Terms Associated with the Libration.* **J. Woltjer, Jr.** (Roy. Astron. Soc., M.N. 81. pp. 603–605, Oct., 1921.)—In the theory of Hyperion terms arise in the satellites' longitude nearly equal to the argument of the libration, and with coefficients containing the square root of Titan's perturbing mass as a divisor, and the eccentricity of Titan's orbit as a factor. With the aid of Delaunay's transformation, the author obtains an explanation of the origin of these critical terms. The numerical value of the two corresponding terms in longitude is $+0''\cdot 202$. W. W. B.

796. *Origin of Comets.* **C. D. Perrine.** (Observatory, 44. pp. 329–331, Nov., 1921.)—A detailed consideration of the two alternative hypotheses of the origin of comets—(1) that they come from inter-stellar space, and (2) that they belong to the solar system, having been ejected from the sun, inclines the author towards the first of these. The main objection alleged against it, namely, the absence of strongly hyperbolic orbits, he meets with the argument that comets have very small masses, and that collisions with resisting media will inevitably reduce any high eccentricities so that there will be practically no strongly hyperbolic comets in any case. Moreover, the preference shown by the aphelia of parabolic and long-period comets for the longitude of the apex and antapex of the solar motion is a strong argument for an external origin. The author also considers the constitution of comets to be unlike that to be reputed if ejected from the sun. Electrical conditions generated within the comet by internal collisions are, he considers, more plausible, as an explanation of observed phenomena, than any hypothesis of solar origin. W. W. B.

797. *Distance and Motion of Præsepe.* **B. W. Sitterly.** (Astron. J. 34. pp. 1–5, Nov. 28, 1921.)—In 1913 Schwarzschild suggested a common motion in space for Boss' Taurus cluster and Præsepe. The author, following Kohlschütter, has compared the two clusters, type for type, on the assumption that all stars brighter than 4·1 mag. in the Taurus cluster and brighter than 7·1 in the Præsepe are giants. The ratio of the parallax of Præsepe to that of the Taurus cluster comes out 0·229 ± 0·017; hence parallax of Præsepe is 0″·0055 ± 0″·0006. The proper motions and radial velocities provide some evidence of connection between the clusters, but the position angles of proper motion are discordant, as they differ by 14°. Various suggestions are made to get over this difficulty, but none of them seems quite satisfactory, and the author concludes that the connection between the two cannot be direct. He considers them to be, therefore, independent members of Drift I. He gives apex of absolute motion, 101° + 18°·7; absolute velocity in space, 30·1 km./sec.; diameter of cluster, 3 parsecs; and number of stars, to 13th magnitude, about 100. W. W. B.

798. *Effective Wave-Lengths of Stars in Relation to Spectral Type and Colour Index.* **C. Davidson** and **E. Martin.** (Roy. Astron. Soc., M.N. 82. pp. 65–77, Dec., 1921.)—Using a grating with bars equal to spaces, the first-order spectrum is of $\frac{1}{10}$ the brightness of the image without grating, the second image disappears, and the third has $\frac{1}{9}$ the brightness of the first, and, being three times as long, $\frac{1}{27}$ the intrinsic brightness. The instrument used was the 30-in. reflector at Greenwich, stopped down to 20 in. to improve definition. The plates were 16 cm. square, covering rather more than 2 degrees square. Two exposures of 10 minutes, two of 2 mins., and on later plates two of 24 secs. for the sake of any bright stars were given. Ilford Special Rapid and Seed Gilt Edge plates were used. The standard density adopted is that given by a 10-min. exposure on a 10th magnitude star. For brighter stars up to 8·5 mag. the 10-min. and 2-min. images are given equal weight. For stars brighter than 8·5 mag., but not brighter than 7 mag., the 10-min. exposure has half weight for stars brighter than 7th mag. The 10-min. exposure is not used except for the third-order image, which is combined with the 2-min. images. Account is taken of atmospheric absorption, both in different zenith distances and in varying degrees of transparency. The region examined specially being within a few degrees of the North Pole, contains very few early type stars, so a few selected B stars from other parts of the sky were included. The tabulated results are compared with those of Lindblad and M. Wolf, and a relation is deduced between wave-length and spectral type. One marked peculiarity is the spreading of the wave-lengths at G5 and K, and this is discussed. A small uncertainty in the type of faint stars will account for much of it, and the fact that dwarfs appear bluer and giants redder in the same class also helps to explain it. Wave-length and colour index are also compared in groups; both Harvard and Mt. Wilson values being given, indicating a colour-equation to the Greenwich photographic magnitudes determined with the 6-in. lens. The method is to be further extended, as it seems promising, and may give a criterion as to the absolute luminosity of stars. W. W. B.

799. *Displacements of Lines in Stellar Spectra.* **P. Salet.** (Bull. Astronomique, 1. No. 5. pp. 273–282, 1921.)—This paper is concerned principally with Arcturus, Procyon, and α Persei, and in a less degree with Sirius and Vega, of which fewer photographs were available. α Persei has been compared with terrestrial metallic spectra, and the other four with the solar spectrum by Hartmann's method. Usually at least ten photographs are used for each star, on account of the smallness of the displacements to be measured; and precautions were taken to avoid systematic and personal errors. The lines chosen are those apparently not affected by pressure, which varies in the atmospheres of different stars [see Abs. 1539 (1921)], nor are they compound lines whose varying intensity in different stars causes an apparent displacement. Lists of lines displaced are given for each star, and also of lines apparently not displaced, except for Sirius, where the data are less complete. The importance is emphasised of insisting that each observer of radial velocity should indicate the lines used in the determination, and that agreement should be reached as to which lines shall be considered "pure," i.e., not displaced by anything else except velocity. W. W. B.

800. *Photographic Magnitude Scale of the North Polar Sequence.* **H. S. Jones.** (Roy. Astron. Soc., M.N. 82. pp. 21–34, Nov., 1921.)—The photographic magnitude of all the stars in the North Polar Sequence down to 13·4 mag. have been determined. The 13-in. Astrographic refractor was used with a parallel-wire grating. The grating gives magnitude differences of 2·83 and 3·48 mag. respectively between central and first two diffracted images. The results are summarised in an accompanying table, and confirm the magnitude scale determined with the 60-in. reflector at Mt. Wilson. There is a close agreement in light-ratio, and not much difference in colour-equation between the two series. W. W. B.

801. *Secondary Oscillations in Light-Curves of Cepheid Variables.* **F. C. Jordan, H. C. Plummer.** (Roy. Astron. Soc., M.N. 82. pp. 38–44, Nov., 1921.)—In recent years Martin and Plummer have published several light-curves of short-period Cepheids, obtained photographically at Dunsink. All show sinuosities in the downward curve, derived from harmonic analysis of observations.

The author compares the Dunsink curves for RR Leonis and SU and SW Draconis with Allegheny curves deduced from much longer series of observations with what he claims to be distinctly smaller individual probable errors, and fails to confirm the Dunsink sinuosities. His conclusion is that the sinuosities are not real, but are introduced by the method used at Dunsink.

Plummer replies to the above criticism. He objects that Jordan has not given details of the Allegheny results, and suggests the possibility that the light-curves are not necessarily the same at different epochs, as to which Martin is recommended to repeat some of them now that several years have elapsed. He derides the idea that the analysis can have introduced any oscillation. Unstable variation was already suspected in SW Draconis, and there is a difference of nine years in the epochs of the two series for SU Draconis, and there is not a great deal of difference between those of RR Leonis. W. W. B.

802. *Variability of Schmidt's Nova Cygni* (1876). **E. E. Barnard** with note by **H. H. Turner.** (Roy. Astron. Soc., M.N. 82. pp. 116–120, Dec., 1921.)—After revising the adopted magnitudes of some of the com parison stars in accordance with corrections derived by Seares from his observations at Mt. Wilson, the author gives his own observations of the magnitude of Nova Cygni from 1901 Nov. to 1921 Oct. He finds unmistakable variability with a range of one magnitude, some of the changes being very sudden. There is indication of a period of about 43 days, but this is uncertain. The image is not perfectly stellar, and the focus is rather greater than that for a normal star, increasing the difficulty of observation.

Turner, in the light of the suggestion of a 43-day period, has taken the well-observed run of observations from 1918 Sept 28 to 1921 Oct. 4, and a rough Fourier analysis points to a period of 41·5 days, with a possible comparison variation in 38 days. Confirmation from earlier observations is not good, and in any case this will not cover the whole of the variation, especially the abrupt changes. W. W. B.

803. *Recent Observations of Novæ.* **W. H. Steavenson.** (Roy. Astron. Soc., M.N. 82. pp. 49–53, Nov., 1921.)—During summer and autumn of 1921, the six novæ, Ophiuchi (1848), Aquilæ (1918), Cygni (1920), Cygni (1876), Lacertæ (1910), and Persei (1901), were kept under regular observation, usually with 6-in. Wray refractor, but at times with one or other of six telescopes, ranging from a 6-in. Cooke refractor to the 28-in. Grubb refractor at Greenwich Observatory.

Nova Ophiuchi shows some evidence of a 50-day period of variability. Nova Aquilæ (1918), slight evidence of a period, about 70 days; and Nova Persei shows marked irregularity of variation. W. W. B.

804. *Spectrum of Nova Cygni III*, 1920. **F. J. M. Stratton.** (Roy. Astron. Soc., M.N. 82. pp. 44–49, Nov., 1921.)—Spectrographs taken at Cambridge on 1920 Aug. 26, 29, Sept. 7, 10, 11, 12, 16, 19, 26, the first two with slit spectrograph on Huggins refractor, the rest with 2-prism slit spectrograph on Newall telescope. The series is too far from complete to solve many of the riddles of the progress of changes, but may fill gaps elsewhere. The displacement of the absorption spectrum is difficult. H-absorption is multiple and very complex, but most of the stronger absorption lines can be simply interpreted as metallic absorption lines displaced by an amount proportional to wave-length. The usual nova group of enhanced spark lines of Fe and Ti give a displacement factor of about $10^4 d\lambda/\lambda = 25$ on Sept. 10 and 11, 24 on Sept. 12, and 27 on Sept. 16 and 19, and these are confirmed by other lines on the same days. No type other than α Cygni seems to be definitely shown on the Cambridge plates.

The bright-band spectrum is given also, as regards the centres of bands about 20 Å. in width, and belonging to clearly traceable origins, single or close double; and displacements are given, some towards red and some towards violet for hydrogen lines. W. W. B.

805. *Pickering Series in O-Type Stars.* **H. H. Plaskett.** (Nature, 108. pp. 209–210, Oct. 13. 1921.)—To test the validity of the identification of the Pickering series of lines (5411, 4542, 4200, etc.), as due to ionised He, advantage was taken of the necessary corollary, that there must be additional lines, appearing as violet components of the Balmer series of hydrogen. Having an average separation of 2 Å., these should be seen readily in O-type spectra. The lines, however, are diffuse, and the

O stars faint. Two selected stars, 10 Lacertæ and 9 Sagittæ, of type Oe5 and magnitudes 4·9 and 6·2 respectively, were photographed at the Dominion Astrophysical Observatory, with 3-prism dispersion, and a scale of 10 Å. to 1 mm. These showed the reputed components to H_β and H_γ, so high-dispersion plates with 9 to 10 hours' exposure were secured of the region about H_α.

The author gives the resulting measured wave-length, and deduces the value of the constant in N_{He} in Bohr's formula, $n = N_{He}(1/4^2 - 1/m^2)$ for several of the lines. Correcting for the motion of the nucleus, he obtains for the mass m_0 in terms of the mass M of the H atom the value 1/1851·6. An improved value is expected from additional plates. He gives reason to doubt the validity of some of Saha's conclusions [see Abs. 1398 (1921)], alleging evidence in a contrary direction. W. W. B.

806. *Parallaxes of 516 Stars from Photographs with 24-in. Refractor.* **A. A. Rambaut.** (Roy. Astron. Soc., M.N. 81. pp. 579–597, Oct., 1921.)—Separate observations of parallaxes of 2408 stars are promised in a future Radcliffe volume. Mean values for 490 stars measured on at least four plates, and 26 specially selected stars on fewer plates are included in the present paper. The parallaxes are corrected for plate-magnitude-error; and are divided into nine groups, including one of the Hyades region and another centred about Nova Persei. Many of the resulting parallaxes are much smaller than their probable errors, and none is so great as a tenth of a second of arc. W. W. B.

807. *Star with Large Proper Motion.* **T. P. Bhaskaran.** (Astron. J. 34. No. 794. p. 11, Dec. 24, 1921.)—Star B.D.—21°·3781, mag. 7·8, on Hyderabad astrographic plates, gave such abnormal differences that it could not be used for determining plate constants. Comparing with the Algiers position 1890·0, the annual P.M. comes out 1″·766 in direction 253°·4. Its parallax should be determined. W. W. B.

808. *Comparison of Trigonometrical with Spectroscopic Parallaxes.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 81. pp. 597–598, Oct., 1921.)—Since writing a previous paper [see Abs. 1239 (1921)], the author has found additional evidence, principally in the list of Adams's 1646 parallaxes, that there is no progressive change in the differences between parallaxes obtained by the two methods. Revising the data used before, in the light of Adams's values of spectroscopic parallax, he finds the difference practically constant, attributable to the parallax of the background stars used in the trigonometrical determinations, so the previously suggested hypothesis falls to the ground. W. W. B.

809. *Spiral Nebulæ in Zones − 40° to − 90°.* **J. H. Reynolds.** (Roy. Astron. Soc., M.N. 81. pp. 598–602, Oct., 1921.)—Very few large photographic reflectors are in the southern hemisphere, so there is little information about spiral nebulæ round the South Pole. The author has re-examined the Franklin-Adams plates. He finds the definition falls off rapidly towards the edges of the plates, so that in the corners very little could be determined beyond the fact that an object was a nebula and not a star. 43 plates were examined. He notes some peculiarities in the distribution of the nebulæ, and promises a further investigation. Special notes are given on the 13 largest nebulæ in the region. W. W. B.

810. *A Star which has perhaps appeared since* 1892. **[Mrs.] I. Roberts.** (Comptes Rendus, 173. pp. 1072–1074, Nov. 28, 1921.)—While comparing Roberts' photographs of stars, clusters, and nebulæ with Lick Observatory photographs of some of the same fields, the author found a star of the tenth magnitude on two of the Lick photographs a little north preceding the nebula H.I. 53, which is not shown on any of the four photographs of this nebula, which were of 43 minutes' exposure on 1887 Oct. 11, of 1hr. 33min. on 1891 Dec. 24, of 2hr. 20min. on 1891 Dec. 27, and of 3h. 39min. on 1892 Oct. 18. A rather fainter star of the same R.A. is shown on all six of the photographs mentioned. The Lick photographs were published undated, but at least one of them must have been taken before 1901, so the author surmises that a nova appeared in Pegasus at some time between 1892 and 1901, but she admits the possibility that the two Lick photographs are really the same twice published, and that what appears as a star may be a photographic defect. Further observation of the region is suggested. W. W. B.

811. *New Elements of Light-Curve of Eclipsing Variable VV Orionis.* **H. Grouiller** and **J. Ellsworth.** (Comptes Rendus, 173. pp. 969–972, Nov. 21, 1921.)—Special attention has been paid to eclipsing variables at Lyons Observatory, assisted by members of the French Association of Variable-star Observers. 300 observations of VV Orionis between 1916 Nov. 3 and 1921 March 11, by J. Ellsworth show considerable residuals when compared with Hertzsprung's elements, giving for minimum 2,418,835·27 days + 1°·4854 E. It seemed probable that the number of periods between one year's observations and the next was inaccurate, and a provisional correction to Hertzsprung's period was adopted, amounting to about 12 minutes. Careful comparison with the approximate provisional period has led to the adoption of a new formula for heliocentric minimum, 2,419,835·27091 + 1°·493824 E. The mean error of a minimum is nearly two hours, which seems large, but the authors attribute this to a small variability in the period, and hope to discuss this when more data are available. W. W. B.

812. *Lines in Visual Spectrum of α Cygni.* **W. H. Wright.** (Lick Observat., Bull. 10. No. 332. pp. 108–109, 1921.)—The author has measured two of the plates obtained by Shane [see Abs. 506 (1922)], and gives a list of the lines found between 5875 and 6800 Å. He has applied a correction for radial velocity, but is not satisfied with it, because the orbital motion of α Cygni has not been determined. W. W. B.

[**813.** *Star Streaming.* **J. C. Kapteyn.** (Engineering, 112. p. 501, Oct. 7, 1921. Paper read before the British Assoc., Edinburgh, Sept., 1921.)—For the two streams of stars first announced by him at the Cape Town meeting in 1905, the author now suggests a dynamic explanation. Imagining the sun at the centre of the galaxy, the equi-density surfaces of the stellar system, where the density was more than 1 % of that near the sun, would be approximately concentric rotation ellipsoids, so that the attraction of the whole on any internal point can be computed if the average mass of a star is known. If the system rotates about the polar axis of the galaxy, the formula for a gas at rest can be applied to stars along the axis. The author finds in this way that at distances from the centre of 198, 413, 717, 1114, and 1660 parsecs the average mass of a star should be respectively 2·2, 2·0, 1·7, 1·5, and 1·4 times that of the sun. These agree very well with mass-determinations from binary stars. For stars in the plane of the galaxy, the addition of centrifugal force to gravitation gives the same masses. At distances of 1014, 2106, 3657, 5675, and 8465 parsecs, linear star velocities of ± 13·0, 19·5, 20·1, 19·4, and 18·6 km./sec. are found. If stars were moving in two opposite directions the relative motion for the majority would be 2 × 19·5 km. = 39 km./sec., which agrees with the relative velocity of the two star-streams. This will account for the streams if we assume, what is *a priori* probable, that the sun is not at the centre. Only stars in galactic plane can have circular motion, but no curvature has yet been detected in the streams. W. W. B.

814. *An Abnormal Star with the Heterochrome Photometer at the Paris Observatory.* **C. Nordmann** and **Le Morvan.** (Comptes Rendus, 174. pp. 101–103, Jan. 9, 1922.)—The star 13 Cephei, a hydrogen star of type A (Harvard), but yellowish (WG), and not white according to Potsdam, seemed a suitable object for colour photometry by the method used before [see Abs. 515 (1922)]. It was observed under good conditions on Oct. 1, 3, 4, 6, and 7, 1921, and compared with Polaris and with two stars near 13 Cephei, one of type A and the other Ma. The ratio of the intensity of 13 Cephei with red screen to that with blue screen is nearly double what it should be for the stars of its type. The deduced effective temperature is about 5130° abs. or lower than that of the sun (type G), or of type F, or of many stars of type K. The authors suggest that the cause of this relatively low figure must be a strongly absorbing atmosphere surrounding the star. It appears, then, that a study of the reversing layers of stars would grade their temperatures differently from the order given by their spectral type. W. W. B.

815. *Colours and Magnitudes in Stellar Clusters.* XIX. *A Photometric Survey of the Pleiades.* **H. Shapley** and **M. L. Richmond.** (Mt. Wilson Observat. Contrib. No. 218. Astrophys, J. 54. pp. 323–333, Dec., 1921.)—*Survey of Photographic and Photo-Visual Magnitudes of* 821 *Stars in Four Square Degrees in the Pleiades.*—The photometric study of a region two degrees square, with Alcyone in the centre, was undertaken to supplement Trumpler's study of the proper motions. The results of measurement of 30 photographs made with the 60-inch reflector, comprising a total of 290 exposures, are given in a table in the original. There are no abnormally large colour-indices. This is the first star cluster for which *comprehensive data for dwarf stars* have been secured. AUTHORS.

816. *Definition of a Nova.* **J. G. Hagen.** (Astrophys, J. 54. pp. 229–236, Nov., 1921.)—*Collision Theory of the Origin of Novæ, Irregular Variables, O Stars, Planetary Nebulæ, and δ Cephei Variables.*—Seeliger's suggestion that temporary stars originate from *encounters between stars and cosmic nebulæ* is made more specific by assuming that the nebulæ are cometary, i.e., become luminous at the approach of the stars, and the possible results of four types of such encounters are discussed. (1) Transit without contact might produce a nova with a relatively small range of variation (type T Boötis ?). (2) Grazing the nebula, if repeated occasionally, might result in an irregular variable such as T Pyxidis. (3) Passage through the nebula on a hyperbolic path might result in a nova of the ordinary type (T Aurigæ) and in a star with a nebulous envelope, an O star. (4) Capture of the star by the nebula might give a δ Cephei variable or a planetary nebula. The theory is shown to account for nearly all the facts of observation relating to ordinary novæ, particularly the range of light, shape of the light-curve, character of the spectrum, their rarity, and their physical similarity to O stars and planetary nebulæ.

The *definition of a nova suggested* by the above theory is "a cometary nebula brought temporarily into close proximity or contact with a bright star." This definition does not include novæ in spiral nebulæ, but fits the four types enumerated. AUTHOR.

817. *Systematic Corrections to Spectroscopic and Trigonometric Parallaxes.* **G. Strömberg.** (Mt. Wilson Observat. Contrib. No. 220. Astrophys. J. 55. pp. 11–19, Jan., 1922.)—The fact that the systematic and accidental errors of spectroscopic parallaxes are proportional to the parallaxes themselves, while the errors in trigonometric parallaxes are independent of the values of the parallaxes, makes it possible, theoretically at least, to determine from a comparison of the two systems the true systematic corrections for each system and even for each observer. The basis of grouping the stars must be independent of each system, and therefore Kapteyn's mean parallaxes, derived from apparent magnitudes and proper motions were used. The factorial correction (x) for the spectroscopic parallaxes and the additive correction (s) for the trigonometric parallaxes, connected by the fundamental equation $x\pi_s = \pi_t + s$, were thus determined. For dwarfs x ranges from 0·97 to 1·07 for different spectral types; for giants the range is from 0·89 to 1·13, the extreme values being rather uncertain. The corresponding systematic correction to absolute magnitudes averages only about 0·1 for dwarfs, but may be somewhat larger for giants. *For the separate observatories,* McCormick, Allegheny, Yerkes, and Mount Wilson, the reductions from relative to absolute parallaxes come out, respectively, + 0″·0053, + 0″·0076, + 0″·0084, and − 0″·0010 within about ± 0″·002. These values agree well with those obtained by van Maanen and Miss Wolfe. Hence the list of 1646 spectroscopic parallaxes recently published from Mount Wilson probably gives the absolute parallaxes without any appreciable systematic error. AUTHOR.

818. *On the System of Procyon.* **J. Lunt.** (Astrophys. J. 55. pp. 71–72, Jan., 1922.)—*Radial and Orbital Velocities of the System of Procyon.*—A series of 45 plates made from 1908 to 1913 give for V_0, after correction for the orbital velocity, the value − 3·52 ± 0·057 km./sec. Taking the parallax at 0″·33 and the masses as 2·70 and 0·89, K comes out 0·60 km./sec. The sign of the inclination is assumed to be positive, but is not definitely known. In order that more accurate information as to the orbit may be obtained, it is hoped that other observatories will co-operate in measuring radial velocities during the next few years, since as favourable an opportunity will not occur again for 39 years.

AUTHOR.

819. *Investigations on Proper Motion.* V. *Internal Motion in Spiral Nebula Messier* 81. **A. van Maanen.** (Mount Wilson Observat. Contrib. No. 214. Astrophys. J. 54. pp. 347–356, Dec., 1921.)—*Spiral Nebula Messier* 81.—Two plates taken at Mount Wilson, one by Ritchey in 1910

and the other by Duncan in 1921, were measured with the new stereocomparator, and from the shifts of 104 points in the nebula with reference to 14 comparison stars, the *proper motion of the nebula* as a whole was found to be: $\mu_\alpha = 0''\cdot014$ and $\mu_\delta = -0''\cdot005$. In addition, when the displacements of the points with reference to the nebula as a whole were corrected for the fact that the *inclination of the plane of the nebula* to the celestial sphere is about 49°, the *internal motion* was found to be in general, a spiral motion out along the arms, of 0″·039 per year N.W.S.E., combined with a slight outward transverse motion of about 0″·007 per year. The rotational component of the motion is 0″·038 and corresponds to a period of rotation of 58,000 years.

Formation of Spiral Nebulæ.—The four nebulæ whose internal motions have been studied, M33, 51, 81, and 101, all have internal spiral motions such as Jeans described in his "Problems of Cosmogony and Stellar Dynamics." This fact *suggests* that the nebulous masses were rotating and had reached a lenticular shape when the arms began to be formed by matter being thrown off at antipodal points. AUTHOR.

820. *Investigations on Proper Motion.* IV. *Internal Motion in the Spiral Nebula Messier* 51. **A. van Maanen.** (Mount Wilson Observat. Contrib. No. 213. Astrophys. J. 54. pp. 237–245, Nov., 1921.)—A comparison of a plate taken by Duncan on April 8, 1921, with one taken by Ritchey on Feb. 7–8, 1910, both at the 25-ft. focus of the 60-in. reflector, enabled the *proper motion of the nebula* and the relative motion of its parts to be determined. Measurements of 80 points of the nebula compared with those of 20 stars give for the nebula an annual proper motion of + 0″·006 in right ascension and + 0″·001 in declination. The *internal proper motion* is not a pure rotation since the mean radial component is outward and is 42 % of the mean tangential component which is 0″·019 E.N.W.S.; rather it is a spiral motion out along the arms at the rate of 0″·021 per year together with a slight outward radial motion of 0″·003.

Two 16th magnitude stars with large proper motions, about 0″·15 per year, were found *near Messier* 51. They are called *f* and *r*. AUTHOR.

821. *Variable Stars.* **L. Pračka.** (Nature, 108. p. 131, Sept. 22, 1921.)—These observations of 72 well-known variable stars were made by Safarik at Prague, and full details of the observations are given, the light-curves and elements being discussed whenever data are sufficient. Colour estimates are included, on Schmidt's numerical scale (0 = white, 4 = yellow, 7 = orange, 9–10 = red). The long-period variables have colour-indices ranging from 7 to 10, S Cephei being an example of the higher index.

Stars treated more fully include R Leonis, R Camelopardi, R Draconis, R Aquilæ, U Cygni, V Cygni, S Cephei, Nova Aurigæ, and Nova (T) Coronæ. W. W. B.

822. *Spectral Evidence of Persistent Aurora.* **V. M. Slipher.** (Lowell Observat. Bull. No. 76. Nature, 109. p. 55, Jan. 12, 1922.—Abstract.)—The yellow-green auroral line contains a considerable proportion of the auroral light. The author, by using a spectrograph with a 66° flint-glass prism, a Dallmeyer lens of *f*/1·9 and isochromatic plates, succeeded in photographing this line in the sky every night he attempted it, whether moonlight or not. It seems therefore probable that this line is always present in the atmosphere. W. W. B.

823. *Effective Wave-Length of Light of Stars in the Galaxy.* **O. Bergstrand.** (Astron. Nachr. Centenary No. Nature, 108. p. 480, Dec. 8, 1921.—Abstract.)—From a series of plates of the star-cloud in Cygnus, obtained with a 15-cm. triple objective prism, the following table results connecting type with effective wave-length :—

O	**411** $\mu\mu$	G	**423** $\mu\mu$
B	**416**	G5	**425**
A	**419**	K	**429**
F	**421**	M	**439**

Only two M stars were available, both probably giants. From the G5 and K stars the author infers that dwarfs have a smaller wave-length than giants of the same type. Analysing the values for fainter stars down to 13·4 mag., the author points out that the percentage of white stars is 60 down to 11·4 mag., and then drops suddenly below 50. He infers that white stars have higher absolute magnitude, and so are more distant than yellow or red stars of the same apparent magnitude. Taking 0·0 for the absolute magnitude of an average giant white star, he finds the radius of our local system to be 2500 parsecs. W. W. B.

824. *Aurora-Line in Night-Sky Spectrum.* **Rayleigh.** (Nature, 108. p. 208, Oct. 13, 1921. Roy. Soc., Proc. 100. pp. 367–378, Jan. 2, 1922.)—At Terling, Essex, the aurora-line can be photographed on two nights out of three. Its ordinary intensity seems to have no connection with magnetic disturbance or sun-spot distribution. At Beaufront, near Hexham, three degrees further north, no single night's exposure showed any trace of the aurora-line, but on two occasions five nights' cumulative exposure there showed it. The same instrument and similar plates were used at the two places, and positive results at Terling were sandwiched between negative results at Beaufront, so that it is not a question of seasonal variation. The author hopes to extend the experiment both northward and southward, in search of a possible explanation. W. W. B.

LIGHT.

825. *X-Ray Diffraction Apparatus.* **W. P. Davey.** (Optical Soc. of America, J. 5. pp. 479–493, Nov., 1921.)—A description is given of an apparatus by means of which the characteristic X-ray diffraction patterns of 15 powdered crystals may be obtained at once. Each pattern is recorded on a strip of photographic film $1\frac{7}{8} \times 6$ in., placed in a cassette which automatically holds the film on the arc of a circle of 8 in. radius, having at its centre the glass tube containing the specimen of powdered crystal. These cassettes are placed radially on a circular horizontal table at a fixed distance from a vertical water-cooled Mo-target Coolidge tube. The 15 specimens thus lie along the edges of a horizontal polygon whose centre is on the axis of the Coolidge tube.

The diffraction patterns obtained are interpreted directly in terms of the interplanar distances in the crystal by means of a scale calibrated in Ångström units. If the crystal happens to belong to the cubic, tetragonal, or hexagonal systems, its structure may be interpreted directly from the interplanar distances by means of the graphs reproduced in the paper. A. B. W.

826. *Speaking Kinematograph.* **E. Viola.** (Accad. Lincei, Atti, 30. ii. pp. 416–419, Nov. 20, 1921.)—Describes the principles underlying the operation of the Emilio Zeppieri system of speaking films. This system employs a mechanical form of connection between film and phonograph record to obtain synchronism. Ordinary standard sizes of films and discs are used, the screen and disc making respectively 120 and 80 revs. per min. Continuous operation of the phonograph record is obtained by arranging that the table carrying one disc when it reaches the end of that disc, automatically starts a second table carrying the second disc, and so allows disc No. 1 to be replaced by No. 3 and so on. Each disc lasts for four minutes, and makes 320 revolutions. Indicator dials are provided for both film and disc so that synchronism can be obtained by the operator after any discontinuity in operation. The author considers that the system effectually solves the problem of speaking kinematography. J. W. T. W.

827. *Apparatus for Projecting Spectra.* **H. Hartridge.** (Cambridge Phil. Soc., Proc. 20. p. 480, Nov., 1921.)—If a Thorpe replica celluloid diffraction grating of about 14,000 lines to the inch be mounted in optical contact with the hypotenuse of a right-angled glass prism, and if now a parallel beam of white light be caused to enter normally at one of the other faces, then it is found, while the direct beam is totally internally reflected and occupies the same position as it would if the prism had no grating mounted on it, that the 1st and 2nd order spectra of one side are found approximately in their normal relationship in regard to the direct beam, but that the spectra of the other side pass out through the hypotenuse of the prism without suffering reflection. If the prism be made of crown glass the yellow region of the 1st order spectrum is in a straight line with the incident beam, and the dispersion of this spectrum is about 54 %

greater than that of the diffraction grating alone. It is also found that (1) the resolving power for a given aperture is increased about 41 %, (2) the purity factor for a given collimator slit width is also increased by about half, (3) the intensity of this spectrum for a given purity and dispersion is also considerably greater than that of the grating alone. It is to this latter feature that the arrangement owes its value. To make use of this spectrum for projection purposes the green, blue, and violet regions of the 2nd order spectrum are screened off by a deep orange colour filter. AUTHOR.

828. *Handy Form of Measuring Microscope.* **T. F. Connolly.** (Optical Soc., Trans. 22. 4. pp. 194–197 ; Disc., 197–198, 1920–1921.)—The instrument comprises a microscope system of relatively low power ; a double-image prism traverses the object space, and is controlled by the rotation of a milled band operating a spiral slot. Exit pupil discs of telescopes or other optical instruments and Brinell impressions can be measured by a single contact setting of the edges of the duplicated discs. The range in the experimental instrument is from 1 to 6 mm., and the accuracy when used with a fixed focus for Brinell impressions is about ± 0·02 mm. The reading scale is very open and is divided to 0·1 mm. No vernier is used. AUTHOR.

829. *Refractometer for Liquids.* **S. Nakamura** and **A. Muramoto.** (Phys. Math. Soc. Japan, Proc. 4. pp. 3–7, Jan., 1922.)—The theory and description of a refractometer for a liquid are given. The principle of the instrument is to find the index from the measurement of the focal length of a liquid lens. The liquid to be tested is placed in a narrow space confined between a glass lens and a plane mirror. A brightly illuminated object is placed before the system and the real image reflected from the system is formed. The image is made to coincide with the object by using an auto-collimating ocular. Such arrangements have already been described by several authors, but they all have the drawback that the reduction formula is not quite simple, and that the index of refraction of glass enters into the expression. The writers show how, by taking an equicurved concavo-convex lens, the index of the lens is made to disappear from the formula, and thus it furnishes a method of absolute determination of the index. AUTHORS.

830. *Interferometer for Testing Camera Lenses.* **F. Twyman.** (Optical Soc., Trans. 22. 4. pp. 174–190 ; Disc., 190–193, 1920–1921. Phil. Mag. 42. pp. 777–793, Nov., 1921. Nature, 107. pp. 635–636, July 14, 1921.—Abstract.)—Describes an interferometer specially designed for the testing of camera lenses of large aperture. For this purpose it is necessary to provide means for rotating the lens about a line at right angles to the axis and passing through the second principal point. It is also necessary to arrange that, simultaneously with the rotation of the lens, the convex back-reflecting mirror shall be automatically moved away from the lens in such a manner that its centre of curvature always falls on the plane, perpendicular to the axis of the lens, on which the lens is desired to form its image. The mechanism by which these desiderata are achieved is described in the paper. The apparatus will test a 32⅜-in. lens up to an obliquity of 5°, and a 21¼-in. lens, and shorter, up to an obliquity of 50°. Photographs are given of the appearance obtained in the cases of lenses affected with each of the five aberrations (excluding chromatic) of a centred optical system. J. W. T. W.

831. *Improvements in Microscopes.* **H. Siedentopf.** (Phys. Zeits. 22. pp. 659–663, Dec. 1, 1921. Paper read at the deut. Physikertag, Jena, Sept., 1921.)—Describes various improvements recently introduced in microscopy, notably in methods of centring the lenses, in the use of double oculars, in the mechanical perfection of the slow motion, and in general design. The paper is essentially descriptive and a summary of progress, and it cannot be usefully abstracted. J. W. T. W.

832. *Eyepiece for Testing the Squaring-on of Telescope Object Glasses.* **F. J. Cheshire.** (Optical Soc., Trans. 22. 5. pp. 235–236, 1920–1921.)

833. *Dependence on Temperature of the Absorption and Refraction of Cinnabar.* **H. Rose.** (Zeits. f. Physik, 6. 3. pp. 165–173, 1921.)—In this research it was found that the absorption limits of the extraordinary ray lie on the average about 9 $\mu\mu$ further in the short-wave direction than those of the ordinary ray. This difference is maintained when the temperature is varied from + 14° to + 260° C. The difference of absorption of the two rays gives rise to weak pleochroism. The absorption was found to be moved about 0·29 $\mu\mu$ towards the long-wave region for 1 deg. C. rise in temperature. Refraction measurements at ordinary temperature were made on five prisms cut from specimens obtained from different localities, and for one prism (from Almaden, Spain) the measurements were extended from − 123° to + 263° C. The five specimens did not give the same results, probably owing to the presence of impurities. The temperature coefficient of refraction was found to increase from 0·12 to 1·65 units in the fourth decimal place for the ordinary ray, and from 0·67 to 3·11 for the extraordinary ray as the absorption region was approached. Babinet's rule that the more strongly absorbed ray corresponds to the higher refraction was not found to hold good for cinnabar. A. W.

834. *Simple Differential Refractometer for Liquids.* **J. S. Anderson.** (Optical Soc., Trans. 22. 3. pp. 156–160, 1920–1921.)—A number of sensitive differential methods for liquids are briefly discussed and a simple new method, which is applicable to a number of problems, is described. AUTHOR.

835. *Double Refraction in a Liquid in Motion.* **A. Pontremoli.** (Accad. Lincei, Atti, 30. ii. pp. 216–220, Sept., 1921.)—A mathematical treatment of double refraction in a rotating medium when the rotation is such that the Fresnel ellipsoid remains unaltered, i.e., the expressions for the motion do not involve the coordinates of this axis. Formulæ are found for the determination of the ordinary and extraordinary rays. J. W. T. W.

836. *Critical-Angle Refractometry.* **J. Guild** and **A. B[arbara] Dale.** (Optical Soc., Trans. 22. 3. pp. 143–152, 1920–1921.)—In this paper the possibilities, for work of high precision, of the critical angle method of measuring the refractive index of a prism are discussed. For general work the method is inferior in convenience and accuracy to the method of minimum deviation, but by a suitable arrangement of the apparatus it can be used to determine refractive indices near 1·53 without the use of a spectrometer, and serves as a useful check on more general methods which depend on the accuracy of a spectrometer circle.

In the second part of the paper the errors of setting in critical-angle refractometry are discussed, and a simple method of determining the necessary correction is described. AUTHORS.

837. *Refractive Indices of Mercury and Thallium Vapours.* **J. C. McLennan.** (Roy. Soc., Proc. 100. pp. 191–200, Nov. 1, 1921.)—Using a method based on that of Parker and Dalladay [Abs. 932 (1917)], it was found possible to make interferometer tubes and hollow prisms of clear fused quartz, free from distortion and all trace of devitrification. With such tubes, determinations were made of the refractive indices for a number of wave-lengths with the vapours of mercury and thallium. The results for Hg vapour are in fairly good agreement with those of Cuthbertson and Metcalfe [Abs. 1082 (1908)]. The dispersion curve for non-luminous Tl vapour indicates the existence of anomalous dispersion at $\lambda 5350 \cdot 65$, and probably also at or near $\lambda 6000$. A. W.

838. *Temperature Coefficient of Electrical Double-Refraction in Fluids.* **N. Lyon.** (Zeits. f. Physik, 8. 1. pp. 64–67, 1921.)—The present paper is in reply to a criticism by Lertes of the author's measurements of the temperature coefficient of double refraction in fluids, and Bergholm's recent confirmatory investigations in the same field [see Abs. 1737 (1921)]. The three theories concerning electrical double refraction are first discussed, namely: (1) the orientation theory of Langevin according to which molecules are polarised and directed in an electric field. The Kerr constant B of electric double refraction is stated by Langevin in the form, $B = C(\epsilon + 2)^2(n^2 + 2)^2 d/Tn$, where ϵ is the dielectric constant, n the refractive index, d the density, T the absolute temperature, and C a term in which all the quantities independent of T are included. (2) The extension to the above theory by Born, who introduces the Reinganum-Debye dipole, which latter should not be appreciably influenced by temperature. Born's amended expression becomes: $B_{(\text{Born})} = B_{(\text{Langevin})} \cdot (1 + M^2/K \cdot T \cdot B)$. When no dipoles are present, the second number vanishes and Born's formula passes into that of Langevin. The presence of dipoles involves the inclusion of the positive term above, and the consequent greater value of B. (3) Gans and Lundblad have further extended the Langevin hypothesis on the assumption that the moments are appreciably influenced by external fields and temperature, thus producing a still more marked temperature dependence of the Kerr constant than assumed by Born. Lertes has now shown that the author's measurements and the conclusions drawn for testing the theory of Langevin and Born are not absolutely binding, since some of the terms such as the dielectric constant and density have to be partly extrapolated for low temperatures. Other measurements by Gans and Isnardi, and by Seitz, Alterthum, and Lechner, are now shown to give good agreement between observed and calculated values on Langevin's formula for carbon disulphide and ether. Born's correction is seen to spoil the agreement, since the calculated values are almost always greater than the observed. The recent measurements by Bergholm ratify and extend the author's values for ether. A possible mistake in the considerations advanced by

Lertes is pointed out, which would involve the contradictory results obtained by him. H. H. Ho.

839. *Visible Refraction and Dispersion of Salts, more especially Coloured Ones, Dissolved in Water.* **G. Limann.** (Zeits. f. Physik, 8. 1. pp. 13–19, 1921.)—The present set of determinations constitutes part of a long series of investigations upon coloured salts made at Rostock [see Abs. 774 (1916)]. Refraction was measured by means of the Pulfrich refractometer for the three hydrogen lines H_α, H_β, H_γ, and partly for sodium light. The solution concentrations were for the most part 0·5, 1, 2, and 4 normal equivalents, and for certain strongly coloured salts 0·3 *N*. The densities and electrical conductivities were measured for the same solutions by Heydweiller, so that the refraction of the dissolved salts as calculated by the earlier method, as well as the optical constants of the ionic solutions, could be extrapolated. The paper is almost entirely devoted to tables of experimental results for a large number of salts. H. H. Ho.

840. *Magnetic Double-Refraction of Liquid Mixtures.* **G. Szivessy.** (Zeits. f. Physik, 7. 4 and 5. pp. 285–286, 1921.)—The author points out that the empirical formula, suggested by Cotton and Mouton for magnetic double refraction in the case of a binary mixture, can be derived from the Langevin theory, in the same way as Bergholm has dealt with the corresponding electric double-refraction phenomenon. The experimental results of Cotton and Mouton [Abs. 1413 (1913)] do not agree with the suggested formula. It would appear that the Langevin theory needs modifying before it can be extended to the case of magnetic double refraction. L. L.

841. *Temperature Coefficients of the Dielectric Constants and the Electrical Double-Refractions of Liquids.* **P. Lertes.** (Zeits. f. Physik, 6. 4. pp. 257–268, 1921.)—Recently [see Abs. 1737 (1921)] Bergholm has published new measurements of the temperature dependence of the dielectric constants and electrical double-refractions of a series of liquids. Bergholm concluded from his data that the theory of the dipole cannot explain the temperature dependence of dielectric constants. This bold assertion is examined in the present paper. Previous work by Boguslawski, Jona, Gans and Isnardi, Herweg, Ratnowski, and Born is referred to. Section 1 deals with the temperature dependence of the dielectric constants, and Section 2 with the electrical double-refractions of toluol, metaxylol, carbon disulphide, chlorbenzene, brombenzene, chloroform, and ethyl ether. It is shown that Bergholm's conclusion is entirely without foundation and invalid. His measurements are in fact a very good qualitative confirmation of the dipole theory and of the consequences derived from it by Born and Gans. The necessity is emphasised for new determinations, under identical conditions, for the same substances, of the dielectric constants, refractive indices, and densities, so that a quantitative confirmation of the theory may be obtained. These conditions have not been observed in the measurements made by Lyon and Wolfram, and Bergholm. Tables of data are included in the paper. H. H. Ho.

842. *The Debye Dipole Theory and the Experimental Results.* **P. Lertes.** (Zeits. f. Physik, 8. 1. pp. 72–76, 1921.)—In a recent paper [see preceding Abs.] dealing with the temperature coefficients of the dielectric constants and with dielectric double-refraction, the author attempted to show that the measurements of Bergholm, Lyon and Wolfram [Abs. 632 (1921)] are in agreement with Debye's dipole theory and the consequences deduced therefrom. The criticism then made has been replied to by both Bergholm and Lyon, the latter dealing only with the temperature dependence of dielectric double-refraction and the former attacking the Debye dipole theory, asserting that neither Debye, Jona, Herweg, nor Lertes has succeeded in establishing a quantitative agreement between the dipole theory and the experimental data. In reply to Lyon, the author points out that his reference to the Gans theory has been confused with Born's theory. The consequences of this misunderstanding are discussed at length. Recent measurements for ethyl ether and carbon disulphide by Lyon and Wolfram are then examined, and Lyon's conclusion noted that contrary to his former result a deviation from the Born theory has to be recorded. Bergholm's criticism of Jona's measurements that no dipoles were found for nitrogen and oxygen is satirically referred to, since these molecules are not polar. Herweg's work is then discussed and shown to be in accordance with the author's views, and finally Bergholm's criticism of the dipole rotation effect is examined. Bergholm shows that for anisotropic molecules in the electrostatic rotation field a similar rotatory effect must occur, and for anisotropic polar molecules, i.e., dipole molecules, the Born theory is valid. In reply it is shown that with anisotropic non-polar molecules, however, a rotatory effect is possible whose magnitude has already been calculated on another basis, but which is very small compared with the effect in polar molecules. On this point the author promises confirmatory data in the near future, obtained from measurements with ethyl alcohol. Finally the author points out an error which Bergholm has made with respect to field strength. H. H. Ho.

843. *The Debye Dipole Theory and the Experimental Results ; a Reply to P. Lertes.* **C. Bergholm.** (Zeits. f. Physik, 8. 1. pp. 68–71, 1921.)— In a previous paper the author has expressed the opinion that the dipole theory appears to be rendered invalid by experimental observations. Lertes [see preceding Abs.] has endeavoured to disprove this conclusion and to show it to be groundless and untenable. The author now discusses the Born formula anew, which latter implies the existence of a permanent molecular moment, and that the product QT of the Kerr constant and the absolute temperature is not constant, but increases with falling temperature. It is now shown that Born has not noticed that the term $J(\epsilon + 2)^2(n^2 + 2)^2 d/n$ is dependent on temperature, since ϵ the dielectric constant, d the density, and n the refractive index are so regulated ; while if the dipole moment vanishes the above product QT must increase with falling temperature. Lertes has based his criticism on this omission, and in consequence his proposals are untenable. In order to decide whether a permanent moment of the molecule exists, the term $R = QTn/(\epsilon + 2)^2(n^2 + 2)^2 d$ is investigated, which latter, according to Born, is $R = a + b/T$, where a and b are constants. Since a and b are held to possess the same sign, R must increase with falling temperature, and the experimental results show that such is not the case, for with all fluids investigated R increases with rising temperature. Lertes quotes the data of Jona, Herweg, and himself in support of Debye's dipole theory, and these are discussed at length. Jona investigated the temperature dependence of the dielectric constant, and his results are shown not to be in accordance with the Debye theory, as also those from Herweg's investigation into the dependence of the dielectric constant on the electric field strength. It is shown that by neither Debye, Jona, Herweg, nor Lertes has a quantitative agreement between the Debye dipole theory, and observation, been established. In consequence the author reasserts his previously expressed opinion. H. H. Ho.

844. *Abolition of Astigmatism for Oblique Rays with a Single Lens (Punktal Lens).* **J. P. C. Southall.** (Optical Soc. of America, J. 5. pp. 398–409, Sept., 1921.)—Describes the problem presented by the design of a single spectacle lens intended to render stigmatic oblique bundles of rays, and points out that the centre of rotation of the eye, and not the centre of the pupil, is the point of reference which must be worked to in this case. The theory is worked out, first for the simplified case of a thin lens where it is shown that the limits between which such a lens is possible are about + 7·8 and − 24·7 dioptres, and finally for the general case, with numerical examples on the use of the formulæ obtained. The stigmatic image surface of such a "punktal" lens will coincide with the "far-point sphere" of the eye only for an unusually strong negative correction, so that normally the eye will have to make a slight effort of accommodation in order to see distinctly in oblique directions through a "punktal" glass. For corrections outside the range possible with a "punktal" lens, a "katral" lens with an aspherical surface has to be employed. J. W. T. W.

845. *Projection as an Aid to Tracing Rays through a Reflecting Prism.* **F. E. Wright.** (Optical Soc. of America, J. 5. pp. 410–419, Sept., 1921.) —Describes the use of a meridian projection diagram for tracing rays through a reflecting prism of any pattern. Each surface of the prism is represented by the point of intersection of its normal with the sphere of projection; similarly a ray is represented by its intersection point, and thus it is easy, given the surface point and the incident ray point, to find the reflected ray point, and this process may be continued for any number of reflections. The case where the normal to the surface and the incident ray are not in the same plane is more complicated. Examples are given of the application of the method to an ordinary right-angled prism, a Porro prism, a Wollaston prism, a Penta prism, and a pentagonal prism. J. W. T. W.

846. *Achromatism.* **H. W. Lee.** (Optical Soc., Trans. 22. 5. pp. 225–232; Disc., 232–234, 1920–1921.)—Various expressions for achromatism are correlated and the usual conditions for achromatism are shown to depend on the tracing of two rays through the system. AUTHOR.

847. *Testing of Heliograph Mirrors and the Measurement of Mirrors of Long Focal Length.* **W. Shackleton.** (Optical Soc., Trans. 22. 4. pp. 167–173, 1920–1921.)—The method of testing the general surface consists in observing the reflection from the mirror of a system of squares on the test board, the magnification given by the mirror being utilised to determine the curvature. The method of examination is applicable to the rapid measurement of mirrors of long focal length. L. H. W.

848. *Seidel's Formulæ for Third-Order Aberrations.* **A. Kerber.** (Zeits. Instrumentenk. 41. pp. 289–299, Oct.; 324–332, Nov.; and pp. 337–348, Dec., 1921.)—A mathematical treatment of the subject in considerable detail which cannot be usefully abstracted. J. W. T. W.

849. *Note on Dispersion Formulæ and the Secondary Spectrum.* **T. Smith.** (Optical Soc., Trans. 22. 3. pp. 99–110, 1920–1921.)—The basis from which dispersion formulæ should be derived for optical glass is considered, and expressions depending on a series of powers of the wave-length investigated, using the figures given in the various Jena glass lists as the criterion for the selection of the index. To obtain further information of the accuracy of the resulting formula, it is applied to Gifford's figures. The comparison in general confirms the conclusion that the expression found, which only differs slightly from Conrady's second formula, is satisfactory, and further leads to the view that Gifford's results may require correction by amounts tabulated. The bearing of the formula on the secondary spectrum of thin lenses is discussed.

AUTHOR.

850. *Aberration Theory of Thin Objectives Constructed with Three or more kinds of Glass.* **T. Smith.** (Optical Soc., Trans. 22. 3. pp. 111–121, 1920–1921.)—General formulæ are developed for the rapid calculation of the aberration coefficients of thin objectives, and special consideration is given to cemented objectives constructed from several different glasses. The most important problem is the knowledge of the influence of the order of the lenses on the spherical aberration in an image (inverted) at magnification unity. With only one lens of each kind of glass this gives 3 cases to be considered with three glasses, 12 cases with four glasses, 60 cases with five glasses, and in general $\frac{1}{2}n\,!$ cases with n glasses. A formula is given for the mean coefficient of all cases, the evaluation of which shows whether an arrangement giving a high, a medium, or a low value of the coefficient is required for the purpose in view. Rules are formulated which indicate where in the series such values are likely to be found.

AUTHOR.

851. *Propagation of Light in a Dispersive Medium.* **L. Brillouin.** (Comptes Rendus, 173. pp. 1167–1170, Dec. 5, 1921.)—In this theoretical paper the author points out that in actual optical media the index of refraction is not unity and it varies with the frequency. This second quality, the dispersion, complicates the laws of propagation of the wave; and it is with a view to calling attention to certain important consequences of this complication that the present note, which cannot well be abbreviated, is written. L. H. W.

852. *Constant-Deviation Prisms.* **R. de Mallemann.** (J. de Physique et le Radium, 2. pp. 390–396, Dec., 1921.)—This paper gives a further discussion of certain properties of constant-deviation prisms previously dealt with by E. Bloch and by G. Bruhat [Abs. 1022 (1919) and 1412 (1921)]. A brief abstract cannot be given. A. W.

853. *Pyramidal Error in Prisms.* **J. Guild.** (Optical Soc., Trans. 22. 3. pp. 139–142, 1920–1921.)—The effect of pyramidal error on the sum of the three angles of a triangular prism is discussed and a convenient method of measuring pyramidal error on an ordinary spectrometer is described. AUTHOR.

854. *Some Problems of Physiological Optics.* **F. K. Richtmyer.** (Optical Soc. of America, J. 5. pp. 461–465, Sept., 1921.—Presidential Address.)

855. *Interference and Reflection in a Moving System.* **J. Le Roux.** (Comptes Rendus, 173. pp. 1343–1344, Dec. 19, 1921.)—The author has already shown that the waves generated by a moving source in an sotropic medium lead to the consideration of ellipsoidal waves of interference and of a parameter of radiation. These same elements occur in the study of the phenomena of interference and reflection for a system of reference S′ moving in a given medium. To every system S′ there corresponds an ellipsoid of interference and a parameter of radiation, independent of all consideration of the moving source connected with this system. Everything is the same as if the system S′ were at rest, when the surface of the spherical wave is replaced by the ellipsoid of interference, and the time by the parameter of radiation. For an observer on the system S′ the medium would still appear to be symmetrical from the point of view of the phenomena considered, but it would not appear isotropic, on account of the Lorentz contraction of the ellipsoid of interference. This is briefly discussed with reference to the Michelson experiment. Results are then given relative to the propagation and reflection of a train of plane waves referred to the moving system S′. It is necessary to consider as the plane of the wave that plane which corresponds to a constant value of the parameter of radiation, and not to a constant value of the time. The direction of propagation is not perpendicular to the plane of the wave; it is parallel to the diameter conjugate to this plane in the ellipsoid of interference. This direction is called the pseudo-normal. The law of reflection at a plane carried along with the moving system S′, can be stated thus: The incident and reflected rays and the pseudo-normal are in the same plane. The two rays are harmonically conjugate with respect to the pseudo-normal and the line of intersection of their plane with the plane of reflection. In order that the reflected ray may coincide with the incident ray for an observer on the system S′, the common direction of the two rays must be that of the pseudo-normal to the plane of the mirror. The plane and the ray are only perpendicular to one another if their direction corresponds to a principal axis of the ellipsoid of interference. These results are deduced from the equation of the partial derivatives for the propagation of waves in an isotropic medium, and therefore only hold good where that equation is valid. A. W.

856. *Dispersion of Water in the Ultra-Violet.* **J. Duclaux** and **P. Jeantet.** (J. de Physique et le Radium, 2. pp. 346–350, Nov., 1921.)—Measurements of the dispersion of water have been made up to the point where it ceases to be transparent. The observations extended to λ1820, but the results have only been worked out as far as λ1862. A comparative method was employed, which is described in detail. The results obtained for the refractive index of water at 20° C. for the wave-lengths $\lambda 2144$ (Cd), $\lambda 1990$ (Al), $\lambda 1862$ (Al) were 1·40437, 1·42572, and 1·45343 respectively, the first of these being in fair agreement with Flatow's result (1·40397) for the same wave-length. Comparing the differences of the refractive indices for the lines $\lambda 1990$ and $\lambda 1862$ (water 0·0277, quartz 0·0233, fluorine 0·0129) it is seen that the dispersion of water is greater than that of quartz, and double that of fluorine. This advantage is augmented by the fact that the mean index of water in this region is smaller than that of fluorine, and much less than that of quartz. A. W.

857. *Dispersion of Gypsum, Augite, and Adular in the Short-Wave Infra-Red.* **E. Goens.** (Zeits. f. Physik, 6. 1. pp. 12–28, 1921.—Abstract of Dissertation, Berlin.)—An investigation was made of the dispersion along the optic axis of symmetry of gypsum, augite, and adular. The range of wave-lengths was $2 \cdot 4\,\mu$ to $12\,\mu$ for gypsum, $8 \cdot 6\,\mu$ to $12 \cdot 8\,\mu$ for augite, and $8 \cdot 2\,\mu$ to $10 \cdot 0\,\mu$ for adular. The position of the optic axis was determined from results of Rubens on the dependence of the transmission or reflection power for monochromatic and linearly polarised light at normal incidence upon the orientation of the plane of oscillation of the electric vector with respect to the crystal. The results obtained for the dispersion and for the principal transmission and reflection powers are shown in tabular form and in a series of diagrams. A. W.

858. *Molecular Scattering of Light in Liquids and Solids.* **C. V. Raman.** (Nature, 108. pp. 402–403, Nov. 24, 1921.)—A knowledge of the scattering power of ordinary liquids, such as water, can be obtained by application of the theory of local fluctuations of density arising from molecular movement, originated by Einstein and v. Smoluchowski, and utilised by the latter to elucidate the phenomena occurring near the critical state. The general formula for the scattering power of a fluid is $(\pi^2/18) \,.\, (RT\beta/N\lambda^4) \,.\, (\mu^2-1)^2 \,.\, (\mu^2+2)^2$, where β is the compressibility of the substance, μ its refractive index, and R, T, N are the usual constants of the kinetic theory. The scattering power of water comes out from this formula as about 160 times that of air. Not only is this in agreement with observation, but it is found that the coefficient of extinction of light due to scattering, namely: $(8\pi^3/27) \,.\, (RT\beta/N\lambda^4) \,.\, (\mu^2-1)^2 \,.\, (\mu^2+2)^2$, closely represents the observed transparency of pure water in the region of the spectrum where there is no selective absorption. Work is now in progress for testing the formula in the case of other liquids. An application of the same idea of local fluctuations of optical density and of Debye's theory would give the theoretical scattering power of transparent crystals for ordinary light. This is also being tested. A. W.

859. *Diffraction of Light by Cylinders and Spheres Immersed in a Medium of Nearly Equal Refractive Index.* **N. K. Sethi.** (Phil. Mag. 42. pp. 669–677, Nov., 1921.)—Experiments are described and discussed in which it is observed that when equal quantities of glycerine and turpentine are shaken together, in addition to the usual Christiansen phenomenon shown by the mixture, the individual drops exhibit interference and diffraction effects, and at ordinary temperatures their edges appear variously coloured. A source of light observed through a single drop of glycerine suspended in turpentine appears surrounded by a number of coloured rings. The case is similar to that of a glass cylinder immersed in a mixture of carbon disulphide and benzene whose refractive index is slightly greater. The fringes obtained in this case are illustrated: their width increases with the angular deviation of the light forming them. Their visibility, very poor at small angles, improves at greater obliquities, falling off again towards the end, where the fringe system terminates in a broad band. With glass spheres these fringes become circular rings with the same characteristics. It is shown that this phenomenon is due to the interference of rays totally reflected from the convex surface of the cylinder or sphere and those twice refracted by them. The distribution of light in the pattern is calculated for a typical case, the results obtained agreeing with the experimental observations both as to the width and visibility of the fringes. At high temperatures, when the refractive index of the glycerine has become greater than that of turpentine throughout the spectrum, the mixture has a peculiar sparkling appearance, probably due to the formation of caustics. Owing to the small difference of refractive indices, caustics of different orders are formed in such quick succession that they may interfere with each other. A glass cylinder immersed in a liquid of slightly lower refractive index gives rise to a series of fringes, broad at small angles and decreasing with increasing obliquity, which differ markedly from those produced when the cylinder has the lower refractive index. A. B. C. L.

860. *Colours of Mixed Plates.* III. **C. V. Raman** and **K. S. Rao.** (Phil. Mag. 42. pp. 679–695, Nov., 1921.)—The theory put forward in Part II [see Abs. 1044 (1921)] of the colours of mixed plates is summarised and equations are given expressing the position of the first and second sets of dark rings existing in the haloes observed. Quantitative data are furnished which are shown to be in complete accord with the theory. The principal phenomena dealt with are: (1) the character of the diffraction halo observed round a light-source viewed through a mixed plate of uniform thickness; (2) the changes in the appearance of a non-uniform film with the angle of observation and especially the blurring of the rings when viewed in certain directions, and the observed influence of the plane of polarisation of the light on the position of the rings; (3) the remarkable asymmetrical character of the haloes observed with obliquely-held plates; and (4) the corresponding phenomena with non-uniform films. A. B. C. L.

861. *Quetelet's Rings and other Allied Phenomena.* **C. V. Raman** and **G. L. Datta.** (Phil. Mag. 42. pp. 826–840, Nov., 1921.)—The general methods of formation of Quetelet's rings are briefly indicated and previous theories referred to. It is shown that hitherto accepted theory requires certain revision. Two novel methods of experimenting are described in which a highly homogeneous scattering film of ammonium chloride on the surface of a plate enables Quetelet's rings to be satisfactorily observed at all incidences up to 90°. An important difference is observed in the configuration of the rings in cases in which the refractive index of the material of the plate is equal to or greater than unity. In the former case the width of the rings diminishes continually from normal to grazing incidence, whereas in the latter the rings first contract, reach a minimum width, and widen out again. The production is described of a new class of Quetelet's rings in which scattered light which has passed twice through the plate interferes with light which has traversed the plate four or six times, undergoing multiple reflection and scattering. Observations made with a sheet of mica of which one surface is dimmed by a film of ammonium chloride show interesting effects, due to the doubly-refracting properties of the plate. The rings seen by white light show dislocations along curved arcs of minimum visibility analogous to those observed in Haidinger's rings by monochromatic light. The interferences observed in Quetelet's rings and allied phenomena do not always have maximum visibility. The contrast between the maxima and minima varies with the magnitude of the phase-differences introduced by passage of the light through the scattering film. An explanation of this is developed in a new treatment of the theory, applicable to the case of a continuous scattering film. The effects of obliquity on the visibility of the rings are also accounted for. A. B. C. L.

862. *Secondary Fringes with Apparatus for Newton's Rings.* **M. Cau** and **D. Chalonge.** (J. de Physique et le Radium, 2. pp. 351–354, Nov., 1921.)—When a convex lens is placed on a sheet of black glass and illuminated with white light at a large angle of incidence, a complex system of fringes may be observed. These fringes, which are rather faint, comprise (1) two series of rings analogous to the ordinary Newton's rings, one series seeming to be identical with the normal system ; (2) a system of fringes with very small curvature, nearly rectilinear and parallel : these are horizontal and extend to the edges of the apparatus. It was found that the complex system is only visible when the light source is limited, as by a diaphragm. An explanation of the origin of the fringes is given. The effects are analogous to the fringes obtained with multiple plates. A. W.

863. *Proposed Standard Method of Colorimetry.* **H. E. Ives.** (Optical Soc. of America, J. 5. pp. 469–478, Nov., 1921.)—The accurate measurement and specification of colour presents difficulties. The choice lies between simple but insufficiently accurate methods, and methods that are unduly complicated or rest on empiricial bases. The author considers that the only unique specification of a colour is by means of spectrophotometric analysis, but the objections to the spectrophotometer for practical work are evident. The author accordingly describes an apparatus for simplifying spectrophotometric measurements, fulfilling the following requirements :—(1) Measurements must be close enough together on the hue scale of the spectrum to enable resultant values completely and uniquely to specify the colour. (2) Individual measurements should be made with portions of the spectrum so narrow that there is no colour difference in the spectrophotometric field at each setting. (3) The entire spectrum must be included by the measurements so that the effect of narrow absorption or emission bands or abrupt changes of intensity with wave-length will not be overlooked. The method consists in measuring adjacent patches of the spectrum, each patch being of width inversely as the hue perception at that point and narrow enough to prevent sensible change of colour. The author describes the apparatus which utilises the principle of the Maxwell colour-box, special slits with movable jaws being provided to facilitate the selection of adjacent spectrum patches. A diagram showing the method of plotting results pictorially is presented. Ideal conditions would mean about 250 patches, but for the vast majority of colours fewer would answer. The apparatus can also be used for reproducing any colour by opening the slits wide, and inserting a sector disc so cut that the radial opening corresponding to each wave-length has the prescribed length. J. S. D.

864. *Optically-Empty Liquids.* **P. Wolski.** (Kolloidchem. Beihefte, 13. pp. 137–164, July, 1920.)—Investigations hitherto conducted on the optical properties of liquids have left in doubt whether the scattering phenomena observed have arisen from foreign particles or molecules or molecular aggregates. The subject is studied in this work by means of (1) the ultra-microscope arranged to give a quantitative evaluation of the optical centres, and (2) by ultra-filtration in order to remove foreign particles. The Siedentopf-Zsigmondy ultra-microscope provided with adjustable horizontal slit illumination was used, and the number of luminous points in a known area of stationary liquid or in a known volume of liquid which was allowed to flow across the field in the objective was counted. Ordinary distilled water gave in this way a value of 29,000 particles per $cm.^3$, corresponding to a distance of separation of 0·3 mm. between each particle. The value for ordinary tap-water was found to be about 30 times as great, while conductivity water obtained by repeated distillations gave very little further improvement over that once distilled. Liquids were also cleared by electrical endosmose.

For ultra-filtration, filters of paper were found to be useless on account of threads which were conveyed to the liquid from the paper. A marked clarification of the liquids was obtained, however, with filters of linen or silk. If, in addition, these materials were coated with a solution of 1 % collodion in alcohol, thereby allowing of a flow of one drop of liquid in 8 secs., the filter after three days' use gave an optically-empty liquid. In the case of solutions of compounds of strong acids with weak bases, such as ferric and aluminium chlorides, a turbidity is given through the colloidal hydroxides of these metals formed by hydrolysis. This turbidity disappears on the addition of a few drops of free acid.

With concentrated solutions of highly soluble substances, such as sugar, great difficulty was experienced in the filtration on account of the high viscosity. However, in all cases, measurements made with a number of inorganic and organic bodies showed that, after filtration through the ultra-filter, no optical heterogeneity was observed, so that the light-centres and turbidity so far obtained are due to suspended impurities. J. N. P.

865. *The Scattering of Light: Note on Wolski's Paper on Optically-Empty Liquids.* **F. B. Kenrick.** (J. Phys. Chem. 26. pp. 72–74, Jan., 1922. Roy. Soc. Canada, Proc. and Trans. 15. Sect. 3. pp. 48–49, 1921.)—An optical examination is made of water after distillation without ebullition. For this purpose, two distillation flasks are taken with their stems sealed together. After admission of water, the apparatus is exhausted. On maintaining the two flasks at different temperatures, water distils to the cooler, and can be rinsed back and re-distilled until dust-free. For optical examination the receiver was constructed in the form of two bulbs connected together at the heads by a short, wide tube and at the bases by a long, narrow U-tube, which was flattened at its lowest point in such a way that its contents could be viewed in the ultra-microscope. The flow of water through this section from one half of the receiver to the other could be regulated by tilting the whole apparatus and a measurement made of the number of light-centres by counting those crossing the field of view in a given time at a known rate of flow.

Ordinary distilled water gave about 2×10^4 light discs per cm.^{3}, which is in agreement with the results of Wolski [see preceding Abs.]. After eight distillations, no more discs were seen. Measurements made of light-scattering showed this effect to be reduced during this interval to only one-tenth of its initial value, so that the scattering is obviously not proportional to the number of motes. The distillation thus removes the ultra-microscopic particles, as in the case of Wolski's filter. Preliminary experiments made with water, after filtering through collodion films to render it optically empty, show that this still exhibits the familiar blue haze seen in all dust-free liquids. J. N. P.

866. *Exposure Determination for Microphotography.* **F. Hauser.** (Zeits. wiss. Phot. 21. pp. 92–97, Oct., 1921.)—Describes a method for finding the correct exposure, under different conditions of magnification and illumination, for any given type of plate or sensitive paper. The method depends on the use of a kind of illuminometer, in which a strip of glass covered with a gradually increasing number of thicknesses of tissue paper is used for determining the condition of equivalent exposure. The illumination is measured by means of a Joly or similar type of photometer, and from a table given in the paper it is possible, from the number of thicknesses of tissue paper, and the ratio of the illuminations in the actual and test conditions, to deduce the correct exposure under any given conditions from the exposure found under the test conditions. If any other kind of plate or paper be employed than that used for the test, the exposure must be further corrected by multiplying by the ratio of the squares of the F numbers of the actual and the test plates. J. W. T. W.

867. *Theory of the Half-Tone Screen.* **L. P. Clerc.** (Phot. J. 61. pp. 311–314, July, 1921.)—The theory of the cross-line screen, which the author worked out in 1908 [see Abs. 1938 (1908)] in collaboration with H. Calmels, follows directly from some investigations published in 1895 by A. K. Tallent and A. W. Dollond on the one hand, and E. Deville on the other. In order to avoid useless repetition the reader is referred to these papers for the justification of the methods adopted. If the apparatus is correctly adjusted, the diaphragm, when examined with the eye situated in the plane of the sharp image, may be regarded as an illuminating surface whose intensity is uniform for any given point of the sharp image, but varies when the eye moves from one point of the image to another. If it be assumed that the document to be copied is replaced by a uniformly illuminated diffusing surface, the area of the diaphragm may be taken as a measure of the max. illumination in the plane of the sharp image. When the cross-line screen is interposed at some distance in front of the plane of the sharp image, a shadow and a penumbra are formed behind each line of the screen; the eye, moving in the plane of the image, does not usually see the entire surface of the diaphragm, but only a variable fraction of this surface. The illumination at each point may be expressed by the uncovered fraction of the area of the diaphragm, in terms of the max. illumination considered above. This fraction may appear entirely within a single mesh of the screen, or on the other hand it may be subdivided by the opaque lines and so appear simultaneously across several meshes. This point is important, because several attempts to explain the theory of the screen have been based on the study of the distribution of the illumination in the light-pencil transmitted by a single mesh of the screen. The measurement of the illumination at each point of the image across the screen is greatly facilitated if, as E. Deville showed, not the diaphragm itself, but its perspective in the plane of the screen pattern is considered, taking various points in the plane of the sharp image in succession as points of view. This perspective is a figure similar to that which bounds the diaphragm aperture, the ratio of similarity being constant, however wrong the point of view, owing to the parallelism of the planes containing respectively the diaphragm, the screen pattern, and the sharp image. The problem therefore resolves itself into calculating for some simple cases, as was suggested by E. Deville, the geometrical positions of points of equal illumination in the image plane, forming the curves which have been named " isophotes." This the author proceeds to do. A solid model representing the phenomena completely is also described and illustrated. A. E. G.

868. *Relation between Sensitiveness and Size of Grain in Photographic Emulsions; Effect of α- and β-Rays.* **T. Svedberg** and **H. Andersson.** (Phot. J. 61. pp. 325–332, Aug., 1921.)—Svedberg has previously published [Abs. 646 (1921)] an account of some measurements concerning the sensitiveness of the different grains in the photographic emulsion. In the present paper those measurements are extended to the effect of α- and β-rays, and a short account is given of the progress made, as well as a survey of Svedberg's previous results. The law of blackening of an ordinary photographic plate—the well-known **S**-shaped " characteristic curve " of Hurter and Driffield—is the mathematical expression of a rather complicated process. Its shape might be due (1) to the inhomogeneity of the field of light in the film, or (2) to the different size and accordingly different sensitiveness of the halide grains, but it may also (3) be a characteristic of the individual halide grain, or (4) of each class of grains of equal size. The supposition (3) has in a way been supported by Trivelli and by Schaum and Bellach, but the experiments of Scheffer, Lüppo-Cramer, and, especially, the important investigations of Sheppard and Mees, go to show that it is only the velocity of reduction, and not the reducibility of the individual halide grain, which varies continually with the exposure. Each halide grain may be looked upon as being either entirely developable, or not developable at all. The behaviour of a halide grain towards a developer should, according to this view, vary with exposure in a discontinuous way: when the exposure has reached a certain minimum limit the grain becomes developable and remains so until the exposure has reached a max. limit—solarisation—when the grain suddenly loses its reducibility. The inhomogeneity of light in the film must, of course, have a certain influence on the blackening law, but according to the experiments of Scheffer and Lüppo-Cramer, working with very thin films containing scarcely more than a single layer of grains, it seems that supposition (1) cannot be maintained. In order to settle the question definitely, the variation of blackening with exposure has been measured for a single-layer plate prepared in the manner described in this paper. The curve plotted from results obtained does not differ essentially from the characteristic curve of an ordinary photographic plate. Accordingly there remain only the two suppositions (2) and (4).

In order to decide between them it is necessary to study somewhat closer the relation between sensitiveness and size of the halide grain in a photographic emulsion. Curves given enable a decision to be made between the two suppositions (2) and (4). The blackening law can hardly be explained by assuming it to depend entirely on the inequality of size of the halide grains; each class of grains of equal size is characterised by a certain curve of exactly the same kind as the S-shaped blackening curve of a photographic plate. This holds good also within the region of solarisation. The sensitiveness increases with the size of grain; thus, for equal exposure the percentage of developable grains is always greater in the class of larger grains.

The experiments of Kinoshita have made it very probable that each halide grain struck by an α-particle is made developable. Some observations of Michl, however, seem to be in opposition to the conclusions which Kinoshita drew from his measurements, and St. Meyer and v. Schweidler are of opinion that not every halide grain that lies in the track of an α-particle, but only a certain fraction of them, is made developable. By means of the methods of measurement here described for the study of the relation between sensitiveness to light and size of grain this question can be settled. A platinum plate covered electrolytically with a layer of polonium served as source of α-rays. The single-layer plates are exposed for various intervals of time to the rays, developed, and freed from silver grains. The halide grains remaining are then measured—in this case not by means of microphotographs, but directly in the microscope by the aid of an ocular-micrometer. The number ν of α-particles striking unit area of the plate per sec. is also measured. ν is found to be 50,000 per cm.^{2}. Now, if the assumption be made that each halide grain that is struck by one or more than one α-particle has become developable, i.e., has received a silver nucleus large enough to act as a condensation centre in the reduction process, then the percentage P of grains of a certain class made developable is given by $P = 100(1 - e^{-A\nu t})$, where A is the cross-section of a halide grain, t = the time of exposure. For experiments with β-rays the procedure was the same as in the case of α-rays. A preliminary test with the formulæ used in the case of α-rays shows that one or even two β-particles striking a halide grain do not as a rule make it developable. It is of interest to notice that an analogous conception might also assist in the interpretation of the action of light. Assuming the quantum hypothesis, the difficulty arises that the real blackening curve has not the exponential form prescribed by this hypothesis if we suppose each halide grain to be made developable when struck by a single light-quantum. On the other hand, if it be assumed that a certain minimum number of quanta must strike the grain within a certain maximum area of the grain in order to build up a silver nucleus large enough to act as a reduction centre, the concept of quanta will actually predict a blackening curve of S-shape. A. E. G.

869. *Relation between Sensitiveness and Grain-Size in Photographic Emulsions.* **F. F. Renwick.** (Phot. J. 61. pp. 333–335; Disc., 335–337, July, 1921.)—Work on this subject is extraordinarily difficult and laborious in character. Experiments in the Ilford laboratories have shown that there is grave danger of inducing chemical fog in dissolving off and diluting the emulsion from a dry-plate, and Svedberg's figures for the percentage of grains developable without exposure indicate that in his experiments something like one-third of the emulsion was fogged in this way. If so, it seems rather hazardous to draw very definite conclusions from the behaviour of the remainder. Svedberg's method of estimating the percentage of developable grains of each size from the percentages left after development and dissolving away the silver, is open to the suspicion that some grains may be incompletely developed and, after clearing of silver, leave residues which would be reckoned as insensitive grains of small size instead of as larger and light-affected grains. The view that statistical methods are the only ones available for attacking the problem is objected to. Some recent experiments indicate that in some directions more certain conclusions can be drawn from carefully controlled emulsion-making experiments. All the evidence goes to show that grain-size and sensitiveness are not mutually interdependent qualities, though in practice it is not known how to vary them independently. The potentialities of an emulsion, i.e., its possible optimum speed, its density-giving properties, and its grain characteristics are largely, and possibly completely, determined at the instant of mixing the reagents. Undue stress seems to have been laid on the subsequent stages of the process of emulsion-making, which merely bring these potentialities to fruition; they are, indeed, in the true sense "ripening" processes, and little more. [See preceding Abs.] A. E. G.

870. *Size-Frequency Distribution of Particles of Silver Halide in Photographic Emulsions and its Relation to Sensitometric Characteristics.* II. *Methods of Determining Size-Frequency Distribution.* **E. P. Wightman** and **S. E. Sheppard.** (J. Phys. Chem. 25. pp. 561–594, Oct., 1921.) —In the first paper of this series [Abs. 1255 (1921)] the question was discussed of a possible relationship between size-frequency distribution of the particles of silver halide in a photographic emulsion and their sensitivity to light action. The present paper deals with methods for determining size-frequency distribution. These are classified as follows: I. *For Microscopic Particles.*—(*a*) Fractionation by gravity (including the ordinary elutriation method), or by centrifugal force, in which the sizes of the particles in the fractions are estimated: (1) By consideration of sedimentation laws (including Westgren's wedge method). (2) By optical control of size determinations. (*b*) Selective filtration methods. II. *For Submicroscopic Particles.*—(*a*) Ultra filtration. (*b*) Fractional coagulation. (*c*) Optical grading by counting in fields of varied light intensity and other optical methods. (*d*) Electrical sedimentation and other sedimentation methods. (*e*) Amplitude of Brownian movement, *per se*, or electric controlled. A new comparatively quick but approximate method of determining size frequency of particles of silver halide in a photographic emulsion has been devised by the author, which depends upon the sedimentation of the halide particles in equal portions of their suspension for increasing lengths of time, and, after resuspending the sediments, counting in a hæmacytometer the number of particles in each of them. At the same time, the weights of the various sediments are found by analysis of the supernatant liquids from each. By application of Stokes' law (Odén's method), or a modification of it, the size frequency is then determined. The paper is also devoted largely to an account of the size-frequency distribution methods, an historical survey of these being given, accompanied by a very complete set of references. The experimental details of the authors' method are given at great length. A brief discussion is given of Stokes' law and its limitations, since it plays a large part in all such experimental work, and the question of its validity has to be taken into account. Perrin has shown that microscopic spherules obey Stokes' law in spite of the Brownian movement. A second more direct, but longer and more tedious, method is described of determining size-frequency of the silver halide particles by counting grain in random samples of emulsion which had been diluted and spread on a microscopic slide. By means of a high-power microscope and camera lucida, the particles are first drawn and then further magnified by projection, planimetered, and classified. A typical size-frequency curve obtained by the latter method was plotted for a high-speed emulsion. The curve plotted from Svedberg's work had the same general shape. The paper also contains a brief notice of work done with submicroscopic particles because of its bearing on the subject in general. The descriptions and references are very complete. H. H. Ho.

871. *Action of Light on Silver Chloride, Silver Bromide, and Silver Iodide.* **P. P. Koch** and **F. Schrader.** (Zeits. f. Physik, 6. 2. pp. 127–131, 1921.)—Experiments made by one of the present authors in conjunction with W. Ehlers [see Abs. 854 (1921)] for the purpose of ascertaining whether the grains of silver bromide show any alteration in mass when acted upon by light have already been described. The results then obtained seemed to prove that with very intense illumination the mass alterations of silver bromide grains are extremely small. The methods then used have been improved upon, and a table of the results obtained with the improved apparatus is here given. The grains of silver chloride, silver bromide, and silver iodide are examined under varying conditions, namely: in room air dried by passing over P_2O_5; in nitrogen dried in a similar manner; in room air moistened by conducting it over water; in moist air from outside; in nitrogen passed over glowing copper and then over water; in nitrogen passed over water; in argon passed over P_2O_5; in argon passed over water; in dust-free air; in nitrogen passed over glowing copper, and then over P_2O_5, etc. The table gives the following data in each case:—Radius in μ of the grains observed; charge of the grains; total time of suspension; duration of the lighting; strength of the lighting; and alteration of mass. The extension of this method of suspension experimentation to stronger lighting, as well as to light of shorter wave-length is in progress. A. E. G.

872. *Relation between Sensitiveness and Size of Grain in Photographic Emulsions.* **S. E. Sheppard** and **A: P. H. Trivelli.** (Eastman Kodak Co.'s Research Lab., Comm. No. 128. Phot. J. 61. pp. 400–403, Nov., 1921.)—It is agreed that there is not a necessary or causal connection between size of grain and light-sensitiveness. On the other hand, it is considered that a contingent or probability relation exists, in that larger grains (or greater projective area) of the same, or lower, absolute sensitiveness have a probability of being brought to a given reactivity which varies with their projective area according to a function of the type suggested by Svedberg and Andersson for α-particles, but where ν is replaced by a function of light-intensity in which quantum considerations are covered. G. Meyer and one of the writers have brought forward evidence in favour of the view that reduction of the grain is preceded by adsorption, and takes place as a breakdown of the adsorption complex of silver halide plus reducing agent, this being accelerated or initiated by the latent image, as silver nucleus. If this view is correct the equilibrium need not, probably could not, be identical with that in aqueous solution—to which physical development after primary fixation would approach. Further, the catalytic effect of silver nuclei probably depends decisively upon their position in relation to a given array of atoms in the silver halide lattice. A final modifying factor necessary to take into account is aggregation of grains in relation to the energy (reduction potential) of the developer. For low reducing energy, developability will not be transferred from one grain, supposed nucleated by exposure, to a contiguous one; in fact, not even the whole of the grain may be developed; for high reducing energy of the developer, a measure of infection of contiguous grains seems very probable. A. E. G.

873. *Sensitivity of Silver Halide Crystals which are Geometrically Identical.* **F. C. Toy.** (Phot. J. 61. pp. 417–421; Disc., 424–425, Dec., 1921.)—The curve obtained by plotting the percentage of grains changed against the logarithm of the exposure for an emulsion containing only one layer of grains enables the sensitivity of the emulsion to be found, and also gives information regarding the relative sensitivity of the individual crystals. The sensitivity differs widely for different crystals if the curve is "flat" and is very nearly constant if the curve is very steep. A vertical straight line (which has never yet been obtained experimentally) would indicate that all the grains were equally sensitive. A problem of primary importance is to discover why different grains differ in sensitiveness, and it can be studied by the investigation of these curves. That the difference in sensitivity of the individual grains can be accounted for by a difference in shape, even though they have the same area, is certainly possible. It is therefore desirable to investigate the curve of an emulsion in which all the grains are geometrically identical. Experiments described show that a variation of the geometrical properties of the grain is not an essential feature of an emulsion in order that it may give the usual type of characteristic curve, and that similarly shaped crystals, which will absorb light energy at the same rate if we assume that the radiation is not discrete, are not all equally sensitive. It is suggested that the reasons to account for this variation in sensitivity may be broadly divided into two classes—(1) those which depend on a variation in the composition of the crystals, and (2) those which depend on the structure of the light radiation and the mechanism of its absorption. A. E. G.

874. *Uniform Development of Dry-plates.* **O. Bloch.** (Phot. J. 61. pp. 425–428; Disc., 428, Dec., 1921.)—Development is essentially a diffusion phenomena, and, in consequence, it is not easy to secure a uniform density over even a small area, since development is most efficient at the edges of the plates owing to the tendency for the amount of reaction product of development to accumulate towards the centre of the dish. Unless the plate is both evenly coated and evenly dried, these defects also give rise to irregularities in the developed density. With X-ray exposures the latent image does not lie principally near the surface, but is distributed through the depth of the emulsion, and irregular rocking has been recommended. In carrying out some work on the behaviour of plates towards X-rays, it was found that the variable results obtained were due to irregularity of development, and experiments led to the adoption of a method of rolling development, which enabled consistent results to be obtained The details of the method now recommended are as follows: The rubber covering of an ordinary roller squeegee (rather wider than the plate to be dealt with) is removed, and the wooden cylindrical core covered with a strip of heavy pile velvet, which is wound spirally around it. The velvet is secured by small brads, care being taken to see that the heads of these are quite at the bottom of the velvet. After the roller has been well soaked in some of the developer the rest is poured over the plate in the usual way, and slow and steady rolling over the surface of the plate commenced at once, and continued until development is completed. No pressure must be used, and the roller should be alternately passed over the face of the plate in two directions at right angles to each other. The roller assists in the removal of exhausted developer from the upper surface of the plate, and helps to supply fresh developer in its place, thus tending to equalise the concentration over the whole plate area. A. E. G.

875. *Colour-Transparency of Ray-Filters in Use at Yerkes Observatory.* **E. C. Bryant.** (Astrophys. J. 55. pp. 1–10, Jan., 1922.)—*Spectro-photometric transmission curves for two ray-filters in use at Yerkes Observatory, and for three coloured glasses used in the Hess-Ives tint photometer* are given for 400 to 750 $\mu\mu$. The filters investigated are J 1, M 1, December 1907, Beta 7, and Beta 10; the glasses are a red, a green, and a blue-violet.

Lemon-Brace Spectrophotometer.—Suggestions as to the adjustment and calibration of this instrument, which was used in obtaining the foregoing curves, are given, and also measurements of the *relative selective absorption of Nicol prism and silver strip* from 475 to 750 $\mu\mu$.

The colour-curve of the 40-in. *objective at Yerkes Observatory* is reproduced. AUTHOR.

876. *"Twin" Crystals and Polarised Light.* **B. Chakrabarti.** (Calcutta Math. Soc., Bull. 12. pp. 145–150, Dec., 1921.)—On examining a twin crystal with convergent plane-polarised light and between crossed nicols, the ordinary rings and brushes are found to be distorted, the amount and the nature of the distortion changing with the orientation of the crystal. The problem of the form of the rings and brushes through a twin crystal has previously been treated mathematically, but the case considered was that where a twinning plane separates two crystals. The problem of two similar crystal wedges separated by a thin twinned lamina inserted between them in an inclined position does not appear to have been solved before, and the present paper deals with this problem both experimentally and theoretically. A. W.

877. *Magnetic Rotation of the Plane of Polarisation in Non-Luminous Sodium Vapour.* **R. Minkowski.** (Ann. d. Physik, 66. 3. pp. 206–226, Dec. 6, 1921.)—The object of the work here described was to determine the magnetic rotation of the plane of polarisation with the D lines in pure sodium vapour, under definite conditions which should be reproducible. Previous determinations have been carried out with temperature and density of the Na vapour not uniform throughout. The apparatus and methods of measurement were largely the same as previously employed by Senftleben [Abs. 1652 (1915)], but special precautions were taken to secure uniformity of temperature and density. The results are given in numerous tables. The mean value derived from the results for the ratio ρ_{D_2}/ρ_{D_1} was $2 \cdot 03 \pm 0 \cdot 09$, this being independent of the temperature. ρ is proportional to the number of dispersion electrons concerned in the absorption of the sodium lines. A. W.

878. *A Polarisation Method of Testing the Gloss of Paper.* **L. R. Ingersoll.** (Am. Illum. Eng. Soc., Trans. 16. pp. 152–158, Aug. 30, 1921.)—Most varieties of paper reflect regularly a part of the light received, and a part is diffusely reflected. The former reflection is objectionable and gives rise to glare. The proportion of light so reflected might be taken as a criterion of " glare " in judging paper. The diffused light is unpolarised, while the directly reflected light is almost completely plane-polarised. This fact is made the basis of operation of a " glarimeter." The quality of paper to be tested is placed horizontally and illuminated by light from a portion of the filament of a glow-lamp, the angle of incidence being about 57°. The eye views the reflected light at the same angle, the rays passing successively through a slit, a Wollaston prism, a lens, and a Nicol prism. Two images of the slit are seen conveying light polarised in planes at right angles. Thus the upper slit-image contains all the specularly reflected component and half the diffused light when the other image emits half the diffused light, but contains none of the directly reflected rays. A position of the analyser can be found at which both images are brought to the same brightness. The angle through which the nicol must be rotated to produce this result serves as an indication of the percentage of specular reflection. It is suggested that on this basis a minimum degree of gloss for school books used by children might be formulated. J. S. D.

879. *Magnetic Birefraction of Fumes Produced by an Arc at Metallic Electrodes.* **L. Tieri.** (Accad. Lincei, Atti, 30. ii. pp. 263–264, Oct., 1921.) —A note by Elihu Thomson on " A Novel Magneto-optical Effect " [see Abs. 1564 (1921)] led the author to form the idea that this phenomenon should be accompanied by magnetic birefraction. The present paper, which is of a preliminary nature, is the result of an examination of this hypothesis. Experimental details are given. The results obtained so far show that by suitably rotating the Nicol analyser the phenomenon of chromatic polarisation is obtained, i.e., with sensibly monochromatic light it is not possible to obtain extinction with rotation of the analyser. With light polarised in a plane parallel or normal to the direction of the field the phenomenon does not take place. A. E. G.

880. *Absorption Spectrum of Europium.* **W. Prandtl.** (Deut. Chem. Ges., Ber. 53B. pp. 1726–1728, Oct. 16, 1920.)—In preparing pure samarium, the author obtained more than 2 kg. of the samarium-magnesium nitrate. The mother-liquor gave the line λ579 sharp, though weak. From the further study of the nitrate solution of europium the author considers that this line is probably Demarçay's band λ590; the other lines comprising a triplet near λ465 (all measured), are likewise sharp, though not intense, and the absorption spectrum is very simple. H. B.

881. *Spectroscopy of Uranium and some Rare Earths.* **G. Meyer.** (Phys. Zeits. 22. pp. 583–585, Disc., 585, Oct. 1 and 15, 1921. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—Research carried out by Greulich showed that with a 72-volt arc between carbon electrodes uranium required a concentration about 500 times greater than Ce, La, Di, Th, in order to develop the ultimate lines of its spectrum. The present paper describes research on the minimum value of the ratio $G = 100U/(U + M)$ for the ultimate lines of uranium to be visible. U and M denote the weights of uranium and some other metal in the mixture of salts used. For Ce, La, Di, and Th the value of G was about unity. For Fe, Ni, Cr, and a number of others the value found was about 7. The same ratio was investigated with Ce, La, Di, and Th substituted for Ur. In most cases the value found was between 1·0 and 0·05. Only in the case of Ce with Na and Ca did the value of G reach 2. A. W.

882. *Temperature and Band Spectra.* **W. Steubing.** (Phys. Zeits. 22. pp. 507–511, Sept. 15, 1921.)—The spectrum of iodine was investigated by special apparatus at temperatures ranging to 450° C. The effects obtained were somewhat complex. For details the original paper, which gives typical blackening curves at various temperatures, should be consulted. [See Abs. 596 (1919).] A. W.

883. *Extension of the Ultra-Violet Spectrum.* **R. A. Millikan.** (Nat. Acad. Sci., Proc. 7. pp. 289–294, Oct., 1921.)—The chief purpose of this investigation [see also Abs. 1421 (1920)] is the exploration, in the extreme ultra-violet, of the radiations which can be emitted by the second ring or shell of electrons in the atoms of atomic number from 2 to 13 (He to Al). The ultra-violet spectrum has been photographed and its wave-lengths determined to $\lambda = 136 \cdot 6$ Å.U. in the case of Al, and to $\lambda = 149 \cdot 5$ Å.U. in the case of copper. There is thus a gap represented by the factor 10 only between the shortest measured ultra-violet waves and the longest X-rays measured by the method of crystal-spectrometry which stops at 13·3 Å.U. The L_{α} lines of Al, Mg, and Na have been photographed and located at 144·3 Å., 232·2 Å., and 372·2 Å. respectively. These wave-lengths are all fairly accurately on the Moseley line connecting L_{α} frequencies and atomic number. It has thus been definitely proved that the L-series continues with its main characteristics unchanged throughout the whole range of atomic numbers from uranium (92) to neon (10).

It has been found that the Al atom (13) where excited by these condensed sparks *in vacuo* emits no radiations whatever of wave-length between 144·3 Å. and about 1200 Å. where its M spectrum, that due to its three outer electrons, begins and extends with considerable complexity into the visible region. This shows that optical spectra are quite like X-ray spectra, in that large gaps occur between the frequencies due to the electrons in successive rings or shells.

Magnesium shows a behaviour similar to that of aluminum. A. B. W.

884. *Emission and Absorption Spectrum of Mercury.* **J. C. McLennan** and **W. W. Shaver.** (Roy. Soc., Proc. 100. pp. 200–217, Nov. 1, 1921.)—Using plates stained with dicyanin, the spectra of a number of the elements have been photographed in the infra-red region. In the case of mercury, 7

the spectrum was photographed up to λ11137. By the photographic method, and also by the use of thalofide cells [Abs. 1477 (1920)], it was found that non-luminous Hg vapour does not absorb radiation of wave-length λ10140. It was, on the other hand, found that slight and scarcely visible deposits of mercury markedly absorb radiation of this wave-length, and this result may explain the observations of Dearle [Abs. 585 (1919)]. By the use of thalofide cells and low-intensity mercury arcs, it was found that radiation of wave-length λ10140 may be strongly absorbed by luminous Hg vapour. From the absence of absorption of radiation of wave-length λ10140 by non-luminous Hg vapour, it follows that the atoms of Hg in their ordinary state do not possess a resonance potential of 1·26 volts, corresponding to λ10140, in addition to the well-established one of 4·9 volts corresponding to λ2536·72. A. W.

885. *Combinations in Band Spectra.* **E. Hulthen.** (Comptes Rendus, 173. pp. 524–526, Sept. 26, 1921.)—From the work of Deslandres [Abs. 1044 and 1203 (1919)] and of Heurlinger [Abs. 1071 (1920)] it is seen that the frequency of a line of band spectrum can be represented as the difference of two frequencies $\nu = \phi(m, n_1, \ldots n_s) - \psi(m', n_1', \ldots n_s')$. The functions ϕ and ψ correspond to the energy of the molecule before and after emission; m and m' are the rotation quanta, while the numbers $n_1 \ldots n_s, n_1' \ldots n_s'$ denote the number of quanta assigned to the other degrees of freedom of the molecule. A single system of bands is obtained by the changes m to m'. Conformably to a general rule of Bohr, the changes m to m' are limited by the conditions $m' = m \pm 1$ or $m' = m$. Hence a system of bands can be represented simply by the formulæ $\mathrm{P}(m)=\mathrm{F}(m)-f(m+1)$, $\mathrm{Q}(m)=\mathrm{F}(m)-f(m)$, $\mathrm{R}(m)=\mathrm{F}(m)-f(m-1) \ldots$ (1), which correspond to the series of the system. Frequently one of these series, the series Q, is not visible. From (1) we have $\mathrm{Q}(m) - \mathrm{P}(m) = \mathrm{R}(m+1) - \mathrm{Q}(m+1) \ldots$ (2). This relation of Heurlinger's has been verified for the band spectra of water-vapour, magnesium hydride, etc. The scheme (1) represents these spectra approximately. On the other hand, the complicated spectrum of carbide of hydrogen at λ4300, formed of two PQR systems, is completely in agreement with the relation (2).

The spectra of zinc, cadmium, and mercury form a new class of band spectra and are of great interest on account of their common structure and of their numerous relations to one another. Tables are given of the zinc bands λ4297 and λ4236, and these are examined in conjunction with the measurements of Liuse for the mercury bands λ4213 and λ4010. It is shown that the following relations hold:

$$\mathrm{R}_1^k(m) - \mathrm{R}_3^k(m) = \mathrm{P}_3^k(m) - \mathrm{P}_1^k(m), \ldots . \quad (3)$$

$$\mathrm{R}_2^k(m+1) - \mathrm{R}_3^k(m+1) = \mathrm{P}_3^k(m-1) - \mathrm{P}_2^k(m-1), \ldots . \quad (4)$$

where $k = 1, 2$. In general these relations appear correct within the limits of error. Only for the zinc band λ4236 do we find appreciable deviations from the relation (4), but the arrangement of the series is a little uncertain. The differences (3) are found to be the same for the two systems of mercury (λ4213 and λ4010). Further work on the mercury bands is in progress. A. W.

886. *Series in the Arc Spectrum of Mercury.* **H. Dingle.** (Roy. Soc., Proc. 100. pp. 167–181, Nov. 1, 1921.)—The generally accepted analysis of the arc spectrum of mercury into series is scattered throughout a number of papers by Paschen and a paper by Wiedmann. It shows the spectrum to contain a triplet and a singlet system of lines. Each system comprises the four main types of series, and there are combinations and intercombinations among the systems. The system is partly collected by Dunz and again by McLennan [Abs. 62 (1913)], but in neither case is the complete arrangement given. Such a collection presents difficulties, especially with regard to the diffuse triplet and singlet series and their combinations. These difficulties are overcome by a new arrangement presented in the present paper. The triplets are associated with certain singlet series, and converted into quadruplets. From the tables given, so far as numerical relations are concerned, the evidence for the recognition of quadruplets is complete. The characters of the lines, also, in the series which have been brought together, are quite in keeping with such association. In the arrangement suggested, the spectrum consists of series of quadruplets and singlets. Five singlet series are recorded including principal, diffuse, sharp, and two combination series. The three main series have been identified on the ground that they show the customary relations between the limits of such series. With the exception of the terms *m*P, the whole of the singlet system can be derived from the quadruplets. If, therefore, the origin of the *m*P terms could be found in the quadruplet system, the whole group of singlet series would become combinations, and the spectrum, so far as it is classified, would consist entirely of a quadruplet system and its derivatives. A. W.

887. *Spectrum of Ionised Potassium.* **J. C. McLennan.** (Roy. Soc., Proc. 100. pp. 182–190, Nov. 1, 1921.)—Sommerfeld has pointed out that the configurations of the extra-nuclear electron systems of the positive ions of the alkali metals are likely to be identical with the configurations of the extra-nuclear electron systems of the atoms of the rare gases. This is shown in diagrammatic representations of the structure of the atoms of H, Li, Na, K, He, Ne, Ar, in which the number of extra-nuclear electrons associated with the atoms is determined by the atomic numbers. Moreover, the atoms of the alkali metals are similar in that they all have but one electron in their outside ring. Their similarity in this respect is paralleled by the fact that in the arc spectra of the alkali elements the wave-lengths can be grouped into doublet series which are the same in number and the same in type for all the elements in the alkali group. Sommerfeld has further emphasised the view that these doublet series have their origin in the outside ring electron of the atoms of the respective elements. When an element of the alkali group is subjected to spark excitation, it is assumed that the violence of the disturbance to which the atoms are subjected is so great that the outer electron is removed entirely from the atom, and that the radiations which are emitted by them under these circumstances must have their origin in the electrons still remaining. Such radiations would constitute the so-called enhanced spectra. In the case of potassium, when the outer electron is removed, the configuration of the remaining electrons is the same as that of an ordinary atom of argon. It follows, then, that the enhanced spectrum of potassium should be identical in type with the ordinary arc spectrum of argon, but might be expected to appear farther down in the violet, since the nuclear charge is one unit higher than for argon. Argon, when subject to moderate excitation, emits the " red " spectrum, and when violently excited, the "blue" spectrum. Hence it should be possible to cause the atom of potassium to emit three definite and distinct types of spectrum. The first would be the ordinary arc spectrum; the second would correspond with and be similar to the red spectrum of argon; and the third would represent the blue spectrum of this element. It seems clear that in the "ground spectrum" of potassium, discovered by Eder and Valenta, we have the enhanced spectrum of that element; and if Sommerfeld's views are correct, the enhanced spectrum should possess characteristics identical with those of the red argon spectrum, and possibly, too, if the excitation were sufficiently intense, of the blue spectrum. The investigation here described was begun with the object of testing the above views. Preliminary observations of the enhanced spectrum of potassium revealed the existence of a great many lines not previously observed, so wave-length measurements were made of the enhanced spectrum, using a very powerful electrodeless discharge in potassium vapour of low density. The wave-lengths given extend from $\lambda 6050$ to $\lambda 1873$ and include over 150 lines in addition to those previously observed by Schillinger. Reproductions of the spectrum show that the lines, from the point of view of numbers and intensity, fall roughly into two divisions with a certain amount of overlapping. In one division the spectral centre of gravity is approximately at $\lambda 3800$, and in the other near $\lambda 2100$. This suggests that we have here spectra analogous to the ordinary and enhanced spectra of argon, the one with its spectral centre of gravity at $\lambda 3800$ corresponding to the red spectrum of argon and the other to the blue spectrum. It is proposed to analyse the frequencies recorded to see if this parallelism can be established numerically. [See Abs. 444 (1915).] A. W.

888. *Duration of Emission of Spectral Lines in the Quenched Arc.* **C. Ramsauer** and **F. Wolf.** (Ann. d. Physik, 66. 6. pp. 373–395, Feb. 7, 1922.)—In the research here dealt with an arc fed with the vapour of a metal was suddenly quenched by cutting off the current, and measurements were made with special apparatus of the duration of emission of the different spectrum lines after the current was cut off. Measurements were made with Li, Ns, K, Rb, Cs; Mg, Ca, Sr, Ba; and Cu, Zn, and Al. The results are presented in numerous tables. It was found that in such "quenched" arcs the lines of the principal series had by far the longest 'life"; the first subordinate series comes next, and the second subordinate series last. Within all subordinate series the duration of the after-light decreases with increasing term number. The same was found to be the case with the principal series of the alkali metals. A. W.

889. *Structure of the Balmer Series Lines of Hydrogen.* **J. C. McLennan** and **P. Lowe.** (Roy. Soc., Proc. 100. pp. 217–226, Nov. 1, 1921.)—Measurements were made of the doublet separations of the first four members of the Balmer series. The results obtained for $\Delta\lambda$ in Å.U. were:—H_α, $\Delta\lambda = 0{\cdot}154$; H_β, $\Delta\lambda = 0{\cdot}085$; H_γ, $\Delta\lambda = 0{\cdot}062$; H_δ, $\Delta\lambda = 0{\cdot}049$. When these separations were plotted against the squares of the corresponding wave-lengths they were found to lie on a curve which pointed to the vanishing of the doublet separation at the short wave-length limit of the Balmer series. When the electric discharge takes place in hydrogen containing a trace of nitrogen, the lines H_α, H_β,

H_γ, and H_δ were found to consist of triplets. Experiments made to decide whether the third members of the triplets had their origin in the radiations emitted by nitrogen atoms, or in a modification produced by the nitrogen in the radiations emitted by the atoms of hydrogen, were not decisive. A. W.

890. *Breadth of the Absorption Bands of the Rare Earths.* **K. F. Herzfeld.** (Phys. Zeits. 22. pp. 544–546; Disc., 546, Oct. 1 and 15, 1921. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—The breadth of the absorption bands of solid salts of the rare earths is here shown to be related to the Stark-effect, which is due to the oscillation and resulting penetration into the electric fields of neighbouring ions. The theory here developed gives the correct dependence on temperature and order of magnitude of the breadth of the bands. Observations at very low temperatures might give an explanation of the existence of " null-point " energy. In water the strength of the electric field may be estimated. The value found has the order of magnitude 5×10^7 volts/cm. A. W.

891. *Inelastic Impacts of Electrons with Mercury Atoms.* **H. Sponer.** (Zeits. f. Physik, 7. 3. pp. 185–200, 1921.)—The research here described is principally concerned with the determination of the function termed by Seeliger the excitation function for the resonance line of mercury λ2536·7. The chief interest lies in the numerous diagrams representing the experimental results and in the discussion of these. [See Abs. 752 (1919).] A. W.

892. *Line Groups and Internal Quanta.* **R. Götze.** (Ann. d. Physik, 66. 4. pp. 285–292, Dec. 20, 1921.)—This paper deals with groups of lines in the spectra of Ca and Sr (Rydberg's measurements) and of Ba (Popow's measurements) [Abs. 448 (1915)]. The three groups are arranged in a Rydberg scheme, and the horizontal differences are then found to be the known fundamental *d* or *p* differences. The combinations give information relative to the number of internal quanta. The Zeeman types are found to be those demanded by Landé's theory. A. W.

893. *Long-Wave Absorption-Band Spectrum of Water.* **R. Weichmann.** (Phys. Zeits. 22. pp. 535–544; Disc., 544, Oct. 1 and 15, 1921. Paper read at the Deut. Physikertag, Jena, Sept., 1921. Ann. d. Physik, 66. 8. pp. 501–545, March 22, 1922.)—It is shown that a parallel-wire system can be used to obtain the refractive index of fluids with an error of not more than 0·5 %. A description is then given of a generator giving almost monochromatic radiation up to $\lambda = 12$ cm. The resonance curve of this exciter is extremely smooth, and the decrement generally not greater than 0·04. The breadth of the spectral line corresponding to it is only a little greater than $\Delta\lambda = 1$ mm. Investigation of the spectrum of water in the interval $\lambda = 65$ cm. to $\lambda = 27$ cm. showed the existence of three regions of anomalous dispersion, corresponding to three absorption bands. These occur at $\lambda = 549 - 521$, $\lambda = 417 - 411$, and $\lambda = 341 - 312$ mm. The middle band is seen to be the sharpest, the width being only about ½ cm. The results obtained show that it is probable that water possesses in this long-wave region a true absorption-band spectrum. The reason that Rückert found no such absorption-bands was probably due to the fact that his series of measurements were too far away from one another. [See also Abs. 62 (1921)]. A. W.

894. *Ionisation and Excitation Potentials of Nitrogen.* **E. Brandt.** (Zeits. f. Physik, 8. 1. pp. 32–44, 1921.)—Measurements were made of the ionisation potential of nitrogen, using a special vacuum tube with two flat grids and a flat anode and the usual hot-filament kathode. Assuming the resonance potentials of helium to be 20·5 and 21·3 volts, the value found for the ionisation potential of nitrogen was 17·75 volts. Other ionisation points were observed at 25·41 and 30·72 volts. The latter part of the paper deals with the excitation limits of the nitrogen molecule, due to electron impacts. The results obtained show that between 7·5 and 8·2 volts numerous kinks are obtained, giving a kind of band emission. A. W.

895. *Excitation of Soft Characteristic X-Rays.* **O. W. Richardson** and **C. B. Bazzoni.** (Phil. Mag. 42. pp. 1015–1019, Dec., 1921.)—A continuation of previous work [Abs. 1277 (1917)]. The apparatus employed was essentially the same as was used in the earlier work. The emission of radiation has been detected with carbon, molybdenum, copper, and tungsten targets, and in the case of C and Mo the critical potential at which the radiation sets in has been determined with considerable exactness. For carbon this critical potential was found to be about 286 volts, and for Mo radiation was found to set in at 356 volts. If it is admitted that these radiations are soft X-rays excited according to the same laws as hard X-rays, the quantum relation applied to carbon shows that the shortest member of the group must lie between the limits 42·7 and 44·3 Å.U., and is probably very close to 43·4 Å.U. Extrapolating from K_β for Al, using Moseley's relation, K_β for carbon should have a wave-length of 45·5 Å.U. A formula of Uhler's gives 50·25 Å.U. It thus appears practically certain that the radiations observed are the K X-rays of carbon, although a direct proof of this cannot as yet be given. For Mo the quantum relation gives the probable wave-length limit as 34·8 Å.U. Calculation from an empirical formula given by Vegard [Abs. 530 (1918)] shows that the M_α line for molybdenum should have a wave-length of 35·2 Å.U. It would be expected that the radiations would be excited by a voltage corresponding to a frequency somewhat higher than that of the α line of the series, so it is probable that the radiations observed are in this case the M X-rays of molybdenum. A. W.

896. *Emission of Light due to Electronic Impacts.* III. **R. Seeliger** and **E. Schramm.** (Zeits. f. Physik, 7. 2. pp. 93–96, 1921.)—A continuation of previous work [Abs. 184 (1922)]. The method adopted for the research now described was the same as before, with some slight modifications. The "excitation function" was investigated for several argon lines, for lines of helium and parhelium, and also for the many-lined and the band spectrum of nitrogen. Confirmation was obtained of the law deduced from earlier results [Abs. 1173 (1920)]. A. W.

897. *Excitation of Light by Electron Impacts.* IV. **R. Seeliger.** (Phys. Zeits. 22. pp. 610–613; Disc., 613, Nov. 1 and 15, 1921. Paper read at the Deut. Physikertag. Jena, Sept., 1921.)—This paper deals particularly with the behaviour of the individual members of a particular series. The method of research was the same as in earlier work [see preceding Abs. and 184 (1922)]. Numerous curves are given showing the results obtained for hydrogen, helium, parhelium, mercury, and neon. A. W.

898. *Wave-Lengths Longer than 5500 Å. in the Arc Spectra of Yttrium, Lanthanum, and Cerium, and the Preparation of Pure Rare-Earth Elements,* **C. C. Kiess, B. S. Hopkins** and **H. C. Kremers.** (Bureau of Standards, Bull. 17. pp. 318–351 [Sci. Papers No 421], 1921.)—Contains the results derived from a study of the yellow, red, and infra-red regions of the arc spectra of yttrium, lanthanum, and cerium Spectrograms were photographed with the dyes pinacyanol, kryptocyanin, and dicyanin. The rare-earth compounds studied were derived from two sources: From the University of Illinois were obtained the oxalates of yttrium and lanthanum and the oxide of cerium, prepared under the direction of B. S. Hopkins; from Eimer and Amend were obtained the chlorides of yttrium and lanthanum and the nitrate of cerium, the last being a Kahlbaum preparation. In addition to spectrograms of the above-named materials secured with the concave grating spectrograph of the Bureau of Standards there were available for measurement two spectrograms by Eder, of Vienna, with his grating spectrograph. These spectrograms were of yttrium and cerium salts prepared by C. A. v. Welsbach. The tables contain about 175 lines in the spectrum (from 5003 Å. to 7882 Å.) of yttrium, 410 in the spectrum of lanthanum, and about 1700 in that of cerium. Many of the wave-lengths are those of heads of bands which are prominent in the spectra of yttrium and lanthanum.

Part II of this paper, prepared by B. S. Hopkins and H. C. Kremers at the University of Illinois, describes the methods used in purifying the samples of yttrium, lanthanum, and cerium, which were used in this work. AUTHORS.

899. *Resonance Potential and Ionisation in a Mixture of Sodium and Potassium Vapours with Mercury.* **A. Campetti.** (Accad. Lincei, Atti, 30. ii. pp. 261–263, Oct., and pp. 360–363, Nov. 6, 1921.)—A preliminary account of this research has already been published [see Abs. 1133 (1921)]. The experiments have now been extended to include the effect of the presence of mercury vapour of varying pressures upon the potential of ionisation and of resonance of the vapour of sodium or of potassium. The apparatus now employed is substantially the same as that used in the earlier experiments; the modifications are described. The results obtained are shown in both tabular and graphical form and it is concluded that they prove that the presence of mercury vapour alters sensibly the resonance potential of the vapours of sodium and potassium. The action upon the ionisation potential is less well-determined. A. E. G.

900. *Absorption Spectra.* **E. C. C. Baly.** (Nature, 108. pp. 311–313, Nov. 3, 1921.)—This paper gives a brief statement of the author's theory of absorption, which has been dealt with more fully in previous papers [Abs. 891 (1916), 1175 and 1287 (1920), 1197 (1921)]. Some interesting data are given relative to the existence of different phases of any inorganic or organic molecule, each of which has its own energy-content, its own reactivity, its own frequency and power of absorbing light. It is shown that the secondary valency hypothesis advanced by Hantzsch and others does not explain absorption. On the other hand, the author's theory attempts to correlate all the phenomena of absorption and to place them on a quantitative basis, and in this it is to a very large extent successful. The theory also offers a quantitative explanation of the phenomena of reaction and reactivity. A. W.

901. *Duration of Light Emission from Atoms, and the Damping of Spectral Lines.* II. **W. Wien.** (Ann. d. Physik, 66. 4. pp. 229–236, Dec. 20, 1921.)—A continuation of previous work [Abs. 379 (1920)]. Measurements were made of the decay of intensity of nitrogen lines, the apparatus and method being the same as in the earlier work. It was found that the damping constant for the nitrogen bands was approximately half as great as for the nitrogen lines, the value for the latter being nearly the same as found previously for hydrogen and oxygen. Further measurements of the damping for H_β and H_γ gave for the damping constant the values $2a = 4 \cdot 35 \times 10^7$ sec.$^{-1}$, and $2a = 4 \cdot 6 \times 10^7$ sec.$^{-1}$ respectively. Mie found for both H_β and H_γ the value $2a = 4 \cdot 35 \times 10^7$ sec.$^{-1}$. The values now obtained by Wien are somewhat smaller than those obtained in the earlier work, and also somewhat smaller than the value for H_α given by the electron theory, namely: $2a = 5 \cdot 35 \times 10^7$ sec.$^{-1}$. A. W.

902. *Duration of Light Emission from Atoms.* **G. Mie.** (Ann. d. Physik, 66. 4. pp. 237–260, Dec. 20, 1921.)—This paper gives a theoretical discussion of the method and results of W. Wien's work on this subject [Abs. 379 (1920) and preceding Abs.], from which it appears that the brightness curve for canal-ray light only follows an exponential law at a distance from the opening into the observation chamber. Nearer the opening there is a difference between the curves for H_β and H_γ which does not appear to be due to observation errors, the differences being quite systematic. At distances greater than 5 mm. the two curves coincide. The difference in the brightness curves near the opening is in agreement with the theory here developed. A. W.

903. *Effect of Magnetic Field on the Intensity of Spectrum Lines.* **H. P. Waran.** (Cambridge Phil. Soc., Proc. 20. pp. 428–433, Nov., 1921.)—Describes further experimental work [see Abs. 262 and 1567 (1921)]. In order to avoid corrosion of the walls of the capillary of the discharge tube, such as was found by Kent and Frye [Abs. 1280 (1913)] with intense fields and strong currents, quartz tubes were used with moderate field and current values. Under these conditions the results were identical with those previously obtained with glass tubes, so that the effects observed cannot be due to disintegration of the walls. Experiments with a tube having capillaries of different section showed that the effect of confining the discharge to a very narrow capillary was entirely different from that produced by the magnetic field, so that mere reduction of the section of the discharge by the magnetic field does not account for the effects observed. With a tube of H-form the field was applied parallel to the discharge. In this case there was no apparent reduction in the cross-section of the discharge, but the spectroscopic changes were similar.

Effect of Condensed Discharge.—At times there is a great similarity between the effect of a condensed discharge through the tube and that due to the magnetic field, but the two effects are by no means identical. Further work is in progress. A. W.

904. *Anomalous Zeeman-Effect.* II. **A. Landé.** (Zeits. f. Physik, 7. 6. pp. 398–405, 1921.)—In a previous paper [Abs. 132 (1922)] the complex Zeeman type was shown to be related to anomalous *e/m* values. In the present paper the abnormality is based on a modification of Larmor's law concerning the precession of an electron system in a magnetic field. No theoretical justification for this modification can as yet be given. The latter part of the paper deals with the relation of the doublet and triplet effects, and with the anomalous magneto-mechanical effect. [See also Abs. 551 (1922).] A. W.

905. *Inorganic Luminescence.* I. *Influence of the Crystal Form, the Flux Added, and the Fusion Process on Zinc Sulphide.* **E. Tiede** and **A. Schleede.** (Deut. Chem. Ges., Ber. 53B. pp. 1721–1725, Oct. 16, 1920.)—According to Lenard, the phosphorescence of bodies like sulphides requires a sulphide, a flux, and some heavy metal compound and calcination of these materials. The experiments of the authors tend to show that the flux is non-essential, and that the actual process of fusing the materials is decisive. Starting from the purest zinc of Mylius, containing only 10^{-7} Cd, they obtained a non-phosphorescent sphalerite by heating the amorphous ZnS for 48 hours in nitrogen up to 900°. Again the hexagonal crystals of ZnS (wurtzite) produced by sublimation of ZnS in H_2S at temperatures of 1200° was non-phosphorescent. There is therefore no connection between crystal form and phosphorescence, and the apparent effect of the flux may be due to the actual fusion. H. B.

906. *Peculiar Luminescences: Zinc Oxide; Potassium Iodide in Hydrochloric Acid.* **C. Winther.** (Zeits. wiss. Phot. 21. pp. 45–65, Oct., 1921.)—Zinc oxide, dry or as paste with water or glycerin, pressed between a quartz plate and a glass plate, shows a peculiar luminescence when exposed to the light of a quartz mercury-lamp through a slit. When the oxide plate is suddenly moved at right angles to the direction of the rays, the luminescence vanishes instantaneously, but does not attain its full intensity in the new spot hit until after a measureable period. This phenomenon was particularly marked with the glycerin paste, and was not observed at all with many other fluorescent substances tried. In the further study a sector wheel, a spectrograph with a vertical slit, and a screen and wedge of a colouring matter were used so that the upper half of the slit could be covered by the screen and the lower half by the wedge. The variation seems to produce, slowly and reversibly in the zinc oxide, a substance which fluoresces visibly but phosphoresces invisibly. The presence of some chemicals has an influence; viscosity, acidity, and zinc salts have not, but impurities probably play a part. When potassium iodide is dissolved in hydrochloric acid, a luminescence which is photographically active, may be observed which seems to be connected with the precipitation of crystals of KCl. Weak acid, below 2 *N*, does not deposit any crystals and does not produce the luminescence which is most pronounced for an acid concentration of 2·75 *N* (between 2 and 5 *N*). The luminescence lasts about 1 second, and is mainly due to rays between 313 and 300 $\mu\mu$. Absorption of moisture first increases the luminescence or calls it forth, certain chemicals (SO_2, etc.) destroy it entirely; when the preparation stands over alcohol or acetone, the luminescence disappears, but it can then be restored by exposure to air. Different preparations of the potassium iodide behave differently, and the influence of impurities is probable; attempts to trace the impurity responsible for the effect have failed. H. B.

907. *Scattering of X-Rays by Atoms of Sodium and Chlorine.* **R. Glocker.** (Zeits. f. Physik, 5. 5 and 6. pp. 389–392, 1921.)—The experimental and the theoretical scattering curves which W. L. Bragg and others [Abs. 1087 (1921)] had deduced from the intensity of the reflection of X-rays by rock-salt were not in agreement. The theoretical curves were based on either of two assumptions: (1) uniform distribution of the electrons on a spherical surface of radius $1 \cdot 02 \times 10^{-8}$ cm. for chlorine and $0 \cdot 67$ for sodium; (2) arrangement of radially oscillating electrons on several spherical surfaces. Applying his extension of Debye's method to several rings, or to spacial arrangement [Abs. 995 (1921)], the author shows that the discrepancy disappears, for both the Na and Cl. In the case of sodium there may either be two rings of quanta 1 and 2, with 2 and 8 electrons respectively, or the 8 external electrons may be at the corners of a cube; both assumptions agreed with Bragg's experimental curve. In the case of chlorine there may be three rings of quanta 1, 2, 3, with 2, 8, 8 electrons, or again a cubical arrangement; with either assumption the accord is not quite so satisfactory as in the case of sodium. There is no need of assuming radial oscillations for the external electrons. H. B.

908. *On the Principle of Combination and Stokes' Law in the X-Ray Series.* **D. Coster.** (Phys. Rev. 19. pp. 20–23, Jan., 1922.)—*New X-Ray Line γ_6 for Elements Tantalum to Uranium.*—The two emission lines γ_2 and γ_3 are found to be in reality three lines. The new line γ_6 has *wave-lengths* of 1110, 1072, 842, 630, and 593×10^{-11} cm. for Ta, W, Tl, Th, and U respectively. In the cases of Ir, Pt, and Au it is too near γ_2 and in the cases of Pb and Bi too near γ_3 to be separated.

New Absorption Lines of the M-Series.—M_{α_1}, M_{α_2}, and M_{α_3} have been measured for *bismuth* and M_{α_4} and M_{α_5} for *thorium and uranium*, the *wave-lengths* being, respectively, 4762, 4569, 3894, 2571, 2388, 2385, and 2228×10^{-11} cm.

Identification of the Line for Tantalum and Tungsten.—For all the elements Os to U, the difference in wave-lengths of $\beta_2 - \beta_5$ is equal to about 29×10^{-11} cm. If this difference is the same for Ta and W also, the β_5 lines for these elements must be the lines $1220 \cdot 8$ and $1250 \cdot 6$, respectively, instead of those ordinarily assumed.

Measurement of L_{α}, and L_{α_2} for tungsten by a different method gave the same wave-lengths as those found by Duane and Patterson.

Relationships between Emission and Absorption X-Ray Spectra.—(1) *Stokes' law* seemed not to hold in the case of W. It was thought the apparent discrepancies might be due to an error in the measurement of L_{α_1} and L_{α_2}, but these measurements were found correct; however, the discrepancies disappear if we identify β_5 with $1220 \cdot 8$ instead of $1212 \cdot 5$ and if we associate γ_2 and γ_3 with L_{α_3} and the new line γ_6 with L_{α_2}. (2) *Relations between Frequencies.*—The frequencies of seven of the L-series lines are each approximately equal to the difference between the frequency of an L_{α}-line and that of an M_{α}-line. AUTHOR.

909. *Softening of Secondary X-Rays.* **A. H. Compton.** (Nature, 108, pp. 366–367, Nov. 17, 1921.)—A number of experimenters have noticed that when a beam of X-rays or γ-rays traverses any substance, the secondary rays excited are less penetrating than the primary rays. J. A. Gray and the author have shown that the greater part of this softening is not due, as was first supposed, to a greater scattering of the softer components of the primary beam, but rather to a real change of character of the radiation. Reference is made to experiments by S. J. Plimpton [see Abs. 329 (1922)] which the author has subsequently repeated. It is concluded from these experiments that the softening of the secondary X-rays is due, not to scattering, but to the excitation of a fluorescent radiation in the radiator.

J. A. Gray (*ibid.*, p. 435, Dec. 1, 1921.) A. B. W.

910. *X-Rays of Long Wave-Length.* **F. Holweck.** (Ann. de Physique, 17. pp. 5–53, Jan.–Feb., 1922.)—Describes a series of investigations on the production and study of rays of length intermediate between those of ordinary light and of X-rays. The first section of the paper deals with the history of the subject; the second, with the experimental arrangements now employed to produce the soft X-rays and to measure the coefficients of absorption of the radiation. In the third chapter experiments are described relating to the minimum p.d. under which an ionising radiation can be detected.

The coefficient of absorption of the soft radiation in various gases has been determined, and the law of variation of absorption as a function of the wave-length of the rays; similarly the absorption coefficient of the rays in celluloid has been determined. These measurements have been made, in a more or less continuous fashion, over the whole range of wave-lengths from visible light-rays to X-rays. Various secondary investigations are also described, in one of which an attempt was made to reflect the soft radiation. A. B. W.

911. *Energy Distribution in the Continuous X-Ray Spectrum.* **A. March.** (Phys. Zeits. 22. pp. 429–438, Aug. 1, 1921.)—In a previous paper [see Abs. 144 (1922)] the author has dealt with the theory of the X-ray "Bremsspectrum." The present paper is a mathematical investigation of the theory of energy distribution in the continuous X-ray spectrum. A. B. W.

912. *Complexity of the K-Series of the Light Elements.* **A. Dauvillier.** (Comptes Rendus, 174. pp. 443–445, Feb. 13, 1922.)—In an earlier paper [see Abs. 1088 (1921)] N. Stensson has referred to the discovery of 10 components in the K-series of copper, only 4 of these having been previously known for this substance. Using the same experimental conditions, an investigation is now described of the K-series of molybdenum, but without observing certain other rays which were found by Duane. The lines α_7, α_3, α_4, β_3, and γ_3 for Mo do not exist. Also the line α_3 (of Duane for tungsten) does not exist for Cu or Mo, and as its existence is contrary to the requirements of the principles of selection, its reality appears to be more and more doubtful. A. B. W.

913. *Influence of Spectrometer Crystal on the Continuous X-Ray Spectrum.* **H. Küstner.** (Zeits. f. Physik, 7. 2. pp. 97–110, 1921.)—If it is desired to investigate the continuous X-ray spectrum by means of a crystal spectrometer and to obtain the intensity distribution in the spectrum as a function of the wave-length, it is necessary to eliminate the influence of the spectrometer-crystal from this function. The author now discusses theoretical means of eliminating the characteristics of the analysing crystal and thence of obtaining reliable data relating to the continuous X-ray spectrum. A. B. W.

914. *X-Ray Spectra.* **E. Hjalmar.** (Zeits. f. Physik, 7. 4 and 5. pp. 341–350, 1921.)—A description was given in an earlier paper, of an investigation of the B-lines of the K-series of X-ray spectra [see Abs. 1176 (1920)]. Since then, the author has investigated the fine structure of these lines and has discovered and measured more components of the KB_1 lines. Photometric curves are now given of the B-lines for the elements S, K, Ca, Si, Ti, Va, Fe, Co, Ni, Cu, and Zn; the results of all observations being included in numerous tables. A. B. W.

RADIO-ACTIVITY.

915. *Radio-Activity of Oxides of Uranium.* **C. Staehling.** (Comptes Rendus, 173. pp. 1468–1471, Dec. 27, 1921.)—The paper deals with a continuation of the author's earlier experiments on this subject [see Abs. No. 388 (1920)]. Certain peculiarities in the behaviour of the red and black oxides of uranium have now received an explanation. It is shown that the red oxide of uranium, even in a state of great purity, "hydrates" slowly in air, without change in external appearance. This hydration only becomes appreciable after several months and may go on for several years. This phenomenon explains the remarkable radio-active behaviour previously observed, for by decreasing the superficial density of the uranium layer, it affects the absorption of the α-rays.

The black oxide is, however, not hygroscopic; this behaviour explains why its apparent radio-activity does not diminish, as with the red oxide. The results thus obtained afford a complete explanation of the apparently anomalous behaviour of the red oxide previously observed. A. B. W.

916. *Adsorption of ThB and ThC by Ferric Hydroxide.* **J. A. Cranston** and **R. A. Burnett.** (Chem. Soc., J. 119. pp. 2036–2044, Dec., 1921.)—It is shown that ferric hydroxide adsorbs ThB and ThC in proportions varying regularly with the acidity of the solution. The method is suitable for separating pure ThC only if the acidity is kept above a certain limit. The variation of the ratio of ThB and ThC is continuous, so that the effect seems to be true adsorption and not the formation of a chemical compound between the active matter and the iron. A colloidal theory is suggested to explain the experimental results; it involves the passage of the radio-active matter from the ionic to the colloidal states, the change being governed by the acidity of the solution. A parallelism is indicated between the experimental results and those of v. Hevesy for electro-deposition of the same elements. A. B. W.

917. *Range Measurements with α-Rays.* **H. Geiger.** (Zeits. f. Physik, 8. 1. pp. 45–57, 1921. From the Physikal.-Techn. Reichsanstalt.)—Reference is made to previous papers on this subject by Geiger and Nuttall [see Abs. 163 (1912)], Wolff [Abs. 997 (1920)], and others. Further refinements in methods of determining range are now described, and the following table of ranges, etc., is given as the most probable values :—

Substance.	No. of Measurements.	Range in cm.		Mean Error, ± cm.	Velocity in cm./sec. × 10^9.	No. of Ion-pairs × 10^5.
		at 0° C.	at 15° C.			
Uran. I.	—	2·531	2·67	very uncertain	1·396	1·33
Uran. II.	—	2·910	3·07	0·1	1·462	1·43
Ionium	3	3·028	3·194	0·016	1·482	1·46
Radium	10	3·212	3·389	0·009	1·511	1·52
Rad. Em	8	3·907	4·122	0·009	1·613	1·71
Rad. A.........	8	4·476	4·722	0·010	1·688	1·87
Rad. C′........	12	6·608	6·971	0·004	1·922	2·37
Rad. F	11	3·721	3·925	0·004	1·587	1·67
Protactinium ..	9	3·482	3·673	0·042	1·552	1·60
Radio do. ...	6	4·432	4·676	0·025	1·683	1·87
Act. X	9	4·141	4·369	0·019	1·645	1·78
Act. Em	9	5·487	5·789	0·017	1·807	2·11
Act. A	9	6·241	6·584	0·010	1·886	2·28
Act. C..........	9	5·224	5·511	0·006	1·777	2·05
Thorium	—	2·749	2·90	very uncertain	1·435	1·37
Radio-thorium..	7	3·810	4·019	0·005	1·600	1·69
Thor. X	7	4·127	4·354	0·010	1·643	1·77
Thor. Em	7	4·799	5·063	0·007	1·728	1·95
Thor. A........	7	5·387	5·683	0·008	1·796	2·09
Thor. C	8	4·538	4·787	0·009	1·696	1·89
Thor. C′	8	8·168	8·617	0·007	2·063	2·74

A. B. W.

918. *Artificial Disintegration of Light Elements.* **E. Rutherford** and **J. Chadwick.** (Phil. Mag. 42. pp. 809–825, Nov., 1921.)—In previous papers Rutherford has shown that when swift α-particles pass through dry air or nitrogen, a few long-range particles are produced which can be detected by their scintillations on a zinc-sulphide screen. These particles were deflected in a magnetic field to about the same extent as swift H-atoms of the same range, and it was concluded that some of the nitrogen atoms were disintegrated by the intense collisions with α-particles and that a positively-charged hydrogen atom (H-atom) was liberated at a high speed. The number observed was very small and their scintillation effects very weak. Recently the optical arrangements for observing the scintillations have been greatly improved and the results are now more certain. In the present paper an account is given of the general methods employed in examining other elements for the emission of long-range particles when bombarded by α-particles, and also a more detailed account of the variation in the number of particles with velocity of the incident α-rays for two typical elements, namely, nitrogen and aluminium. The following table contains a list of elements examined, with the number and range of the long-range particles emitted. Only ranges greater than 32 cm. were considered, this being a little greater than the range of H-atoms produced in air or nitrogen.

Element.	Material.	No. of Particles per min. per mgm.	Max. Range in cm. of Air.
Lithium	Li_2O	—	—
Beryllium	BeO	—	—
Boron	B	0·15	c. 45
Carbon	CO_2	—	—
Nitrogen	Air	0·7	40
Oxygen	O_2	—	—
Fluorine	CaF_2	0·4	over 40
Sodium	Na_2O	0·2	c. 42
Magnesium	MgO	—	—
Aluminium	Al . Al_2O_3	1·1	90
Silicon	Si	—	—
Phosphorus	P (red)	0·7	c. 65
Sulphur	S, SO_2	—	—

In addition to the above, the following elements of higher atomic weight were examined: Chlorine as $MgCl_2$; potassium as KCl; calcium as CaO; titanium as Ti_2O_3; manganese as MnO_2; iron, copper, tin, silver, and gold in the form of metal foils. In no case were any particles observed of range greater than 32 cm. of air. The question whether any of these elements give particles of range less than 32 cm. has not yet been examined.

It is of interest to note that of the elements so far examined only those whose atomic mass is given by $(4n + 2)$ or $(4n + 3)$, where n is a whole number, give rise to H-atoms. Elements of mass $4n$, like carbon, oxygen, sulphur, show no effect. Such a result receives a simple explanation on the assumption that the nuclei of these elements are built up of helium nuclei of mass 4 and of hydrogen nuclei.

The paper concludes with a general discussion of the mechanism of this artificial disintegration and the bearing of the results on the nuclear structure of atoms. A. B. W.

919. *Recoil of Hydrogen Nuclei from Swift α-Particles.* **A. L. McAulay.** (Phil. Mag. 42. pp. 892–904, Dec., 1921.)—This investigation was undertaken with the object of obtaining the number of hydrogen atoms recoiling at various angles from a homogeneous α-ray beam, and thence of deducing information bearing on the nature of the collision and the size of the colliding particles. An ionisation method was used similar in principle to one described by the author in a recent paper [Abs. 464 (1921)], but with improved apparatus. A. B. W.

920. *Collisions of α-Particles with Hydrogen Nuclei.* **J. Chadwick** and **E. S. Bieler.** (Phil. Mag. 42. pp. 923–940, Dec., 1921.)—The authors describe an experimental investigation of the relations which hold in the collisions between α-particles and H-nuclei. The angular distribution of the H-particles projected by α-particles of mean range 6·6 cm. has been determined up to an angle of 66°. The distribution for α-rays of mean ranges 8·2, 4·3, and 2·9 cm. has been obtained over a smaller range of angle. It is shown that the number of H-particles projected within these angles by α-rays of high velocity is greatly in excess of that given by forces varying as the inverse square of the distance between the centres of the two nuclei.

The variation in the number of H-particles projected within a given angle with the velocity of the α-rays has been observed over a wide range. It is shown that for α-rays of high velocity the variation is in the opposite direction to that given by the inverse square law; for α-rays of range less than 2 cm. (velocity less than $1 \cdot 26 \times 10^9$ cm. per sec.), however, the collision relation is about the same as that given by the inverse square law.

The experimental collision relation is compared with those calculated by C. G. Darwin for various models of α-particle, and the conclusion is reached that the α-particle behaves in these collisions as an elastic oblate spheroid of semi-axes about 8×10^{-13} and 4×10^{-13} cm., moving in the direction of its minor axis. Outside this surface the force varies approximately as the inverse square of the distance from the centre of the spheroid.

A. B. W.

921. *Determination of Thorium in Monazite Sand by an Emanation Method.* **H. H. Helmick.** (Am. Chem. Soc., J. 43. pp. 2003–2014, Sept., 1921.)—The author refers to errors in Cartledge's emanation method of determination of thorium in monazite sand [see Abs. 452 (1919)] and describes an improved procedure which avoids such errors. The most important of these was the adsorption of thorium X by suspended matter in final solutions, by filters, and by walls of vessels used. These errors have been avoided in the method now described, by producing a complete solution of the sand without filtration and in a single vessel.

A. B. W.

922. *Radio-Activity of Springs near Bagnoles-de-l'Orne.* **P. Loisel.** (Comptes Rendus, 173. pp. 921–923, Nov. 14, 1921.)—Gives the results of the radio-active analysis. The author traces a relation between the radio-activity of the springs and the geological nature of the ground from which they emerge.

A. B. W.

HEAT.

923. *A Furnace Temperature Regulator.* **H. S. Roberts.** (Washington Acad. Sci., J. 11. pp. 401–409, Oct. 19, 1921.)—The apparatus described is of the bridge type with galvanometric relay, and at 1200° furnace temperature is said to be capable of keeping the temperature constant to ± 0·1 deg. C. for hours without any attention. L. H. W.

924. *Dilatation of Chromium and of Nickel-Chromium Alloys.* **P. Chevenard.** (Comptes Rendus, 174. pp. 109–112, Jan. 9, 1922.)—An investigation of the dilatation of chromium and of the effect of additions of Cr on the dilatation of nickel carried out by means of the author's differential dilatometer [see Abs. 969 (1917)].

Chromium.—The coefficient of expansion of Cr, which is $6\cdot8 \times 10^{-6}$ at 0° C., increases rapidly with rise of temperature.

NiCr Alloys.—The addition of Cr to nickel rapidly reduces the critical point shown, in the neighbourhood of 300° C. by nickel, at the same time lowering the temperature at which the arrest occurs. When 5 % Cr is present the point disappears. J. L. H.

925. *Emissive Power of Metals and Oxides.* **M. Kahanowicz.** (Accad. Lincei, Atti, 30. ii. pp. 132–137, Aug., 1921.)—Describes experiments made to determine the expression for the emissivity of various substances at high temperatures. The substances used were the oxides of iron, copper and nickel, and matted platinum, i.e., platinum covered with platinum black and then heated in an electric furnace. The temperatures (from 600 to 1400° abs.) were measured by means of a le Chatelier element previously described [see Abs. 288 (1918) and 1449 (1920)]. The specimens, consisting of thin plates, were heated in an electric furnace. It was found that the results could be expressed in the form, emissivity $E = CT^4 e^{-c/T}$; where T is the absolute temperatures and C and c are constants having, for the different substances, the following values :—

Iron oxide..............	$C = 1\cdot30 \times 10^{-10}$	$c = 380\cdot5$
Copper oxide	$1\cdot35 \times 10^{-10}$	$422\cdot0$
Nickel oxide	$1\cdot36 \times 10^{-10}$	$504\cdot1$
Platinum (matt)	$1\cdot34 \times 10^{-10}$	$621\cdot8$

The results thus obtained agree well with previous determinations, for nickel oxide by Foote [see Abs. 473 (1915)], and for oxide of iron and platinum by Lummer. For different metals the author finds the following expression to hold : $E = kT^n$, where the constants k and n have the following values :—

Metal.	k.	n.
Platinum	$8\cdot78 \times 10^{-15}$	$5\cdot1$
Gold	$54\cdot30$	$4\cdot9$
Nickel, to 350° C.	$1\cdot28$	$5\cdot5$
Nickel, 380° to 530° C.	$1\cdot14$	$5\cdot5$

It appears that nickel has a point of discontinuity at the critical temperature of magnetism, where it also shows a discontinuity in electrical resistance. The possible effect of direct radiation from the walls of the furnace, or reflection of such radiation from the specimen under measurement, is considered in the paper. J. W. T. W.

926. *The Solidification of Pure Organic Liquids as Thermometric Standards at Temperatures below 0° C.* **J. Timmermans, [Mlle.] H. van der Horst,** and **H. K. Onnes.** (Comptes Rendus, 174. pp. 365–367, Feb. 6, 1922.)—The fixation of a number of thermometric points, furnished by the fusion or ebullition of pure substances, has often been recommended for the purpose of improving the concordance of results obtained by different investigators. The present paper deals with such standard temperatures below 0° C., and the fusion temperatures of nine pure organic substances have been determined, namely: carbon tetrachloride (− 22·9°), chlorobenzene (− 45·2°), chloroform (− 63·5°), ethyl acetate (− 83·6°), toluene (− 95·1°), carbon disulphide (− 111·6°), ethyl ether (− 116·3°), methyl cyclohexane (− 126·4°), and isopentane (− 159·6°). The measurements have been made with a cryostatic apparatus in which the thermodynamic equilibrium between the liquid and crystalline phases could be maintained within 0·01 of a degree over a long interval. Brief details of the apparatus are included. The temperatures were determined by means of a Pt-resistance thermometer calibrated with respect to a helium thermometer. All the substances were purified with the greatest care, and an accuracy within 1/10 of a degree is claimed for the determinations, which are tabulated.
H. H. Ho.

927. *Hydrogen by Partial Liquefaction of Water Gas.* **G. Claude.** (Comptes Rendus, 173. pp. 653–655, Oct. 17, 1921.)—Instead of liquefying water gas for the production of hydrogen, the author had recommended that the gas be dissolved in ordinary ether. He now goes back to liquefaction, but not on the lines of Haber and Linde. The water gas passes through a heat exchanger in which a first separation of CO and H is effected, into a "collector," a multitubular apparatus, from the top of which pure hydrogen escapes. Part of this hydrogen is made to work a piston motor in which it is further cooled by expansion and returned to the collector. This motor first worked badly owing to the want of a suitable lubricant; even petrol ether failed at − 190°. The difficulty is overcome by admitting some nitrogen (5 to 10 %) into the hydrogen pipe feeding the motor; the temperature then goes down to − 210°, the snowy nitrogen lubricates, and there are also other advantages in this addition of nitrogen. H. B.

928. *Comparison of the Temperature Scale of the Reichsanstalt with the Thermodynamic Scale between* 0° *and* 100° *C.* **F. Henning** and **W. Heuse.** (Zeits. f. Physik, 6. 3. pp. 215–223, 1921. From the Physikal.-Techn, Reichsanstalt.)—In the interval between 0° and 100° the basis for the practical scale has been the four mercury thermometers set up by Chappuis in 1887, and compared with the hydrogen thermometer. On the establishment of the scale of the Reichsanstalt, it was decided to adopt as normal scale between − 40° and + 500° C. the pure Pt-resistance thermometer whose resistance is a quadratic function of the temperature, the three constants for which function are determined at melting-point of ice, the temperature of boiling water, and the B.P. of sulphur. As theoretical scale the thermodynamic scale alone need be considered. A sufficiently close realisation of this scale can be obtained from the constant-volume helium thermometer. In the Reichsanstalt a comparison between the platinum, hydrogen, and helium thermometers between + 100° and 450° and between − 190° and − 258° had been made. Between 0° and 100° only there existed a gap for which no comparison data were available. The object of the present paper is to fill this gap. Observations were made on three thermometers and a helium thermometer. The details of the latter instrument have been given [Abs. 589 (1922)]. The Pt thermometers were new, and set up for the purpose in hand. Details of these and the method of making the electrical measurements are included. Tables are given containing the results of observations extending over several days, with a comparison between the two scales. The mean differences between the thermometers are shown below:

t.	He − Pt Thermometers.
20°	+ 0·007 deg.
50°	− 0·005 deg.
80°	+ 0·004 deg.

T. B.

929. *Mutual Action of the Convection Currents Arising from Two Heated Wires.* **J. S. G. Thomas.** (Phil. Mag. 42. pp. 940–955, Dec., 1921.)—The present paper, arising out of an investigation into the distribution of velocities around a fine, heated Pt wire, details results showing how the mutual effect experienced by two fine, heated wires, surrounded by air at atmospheric pressure, is conditioned by their distance apart, and their disposition with regard to the walls of the enclosure containing them. [See Abs. 1507 (1921).] L. H. W.

930. *Convection of Heat by a Turbulent Current of Liquid or Gas.* **H. Latzko.** (Zeits. Math. u. Mechanik, 1. pp. 268–290, Aug., 1921.)—Applies the idea that the transfer of heat and momentum in a fluid is due to one and the same agency (in the case considered, turbulence), and v. Karman's results [see Abs. 718 (1922)] to the calculation of the amount of heat carried away from a solid by a current of fluid. For the case of flow through a tube, the value of the emissivity (heat lost per unit area excess of temperature of wall over mean temperature of fluid at section in question) tends to the value $0{\cdot}0384v\text{C}/\text{R}^{1/4}$ (v = mean vel., C = specific heat, R = Reynolds number); for a plane the value is $0{\cdot}0356v\text{C}/\text{R}$. The conditions near the inlet are considered; and the heating due to viscosity is calculated, and shown to be negligible in any practical case. W. G. B.

931. *Losses by Evaporation of Liquid Air in Vacuum Flasks.* **H. Briggs.** (Roy. Soc. Edinburgh, Proc. 41. 2. pp. 97–110, 1920–1921.)—

There are three ways in which heat from the outside atmosphere may reach liquid air stored in a vacuum flask, namely: (1) by radiation from the relatively warm outer vessel to the cold inner vessel; (2) by conduction across the vacuum space; (3) by conduction down the neck of the flask. The heat radiation may be expressed as $L_R = a(\theta_1^4 - \theta_2^4)$ in which a is a constant depending on the emissivity of the surfaces and upon their dimensions. The heat carried by conduction across the "vacuum" may be represented by $L_c = b(\theta_1 - \theta_2)\sqrt{(\theta_1 + \theta_2)}$, where b is constant for a given bottle. The heat lost by conduction down the neck was determined experimentally by slipping an inner tube of cupro-nickel of the same length as the neck inside the latter, and determining the evaporation rates again at the selected temperatures. The results obtained for a particular metal flask, of capacity about 3 litres, are given below:—

Temp., Outer Globe.	Conduction across Vacuum, gm. per hr.	Radiation, gm. per hr.	Neck Conduction, gm. per hr.	Total Loss, gm. per hr.
10° C.	10·9	20·6	11·0	42·5
15° C.	11·3	22·1	11·9	45·3
44° C.	13·3	32·5	15·4	61·2
70° C.	15·3	44·5	15·2	75·0
100° C.	17·6	62·4	14·6	94·6

A computation of the pressure p in the vacuum space was made from the equation: Heat transferred by conduction across the vacuum $= c(\theta_1 - \theta_2)pA$, where c is a constant known to have a value for air of approximately 2×10^{-5} at 30° C., and A is the area of the surface. For a particular flask, which had been evacuated 20 months when the tests were made, p was found to be 0·00038 mm. of mercury. T. B.

932. *Cooling of a Solid Sphere with a Concentric Core of a Different Material.* **H. S. Carslaw.** (Cambridge Phil. Soc., Proc. 20. pp. 399–410, Nov., 1921.)—The problem solved in this paper is one referred to by Heaviside ("Electromagnetic Theory," 1899, vol. 2, ch. v.), who mentions that he has obtained its solution by his "operational method," but did not publish the work. The same problem (with an incorrect answer) was also set in a Mathematical Tripos paper, 1904. Results obtained of the earth's "age" by Kelvin, Perry, and Heaviside, by mathematical investigations of this nature, do not possess much value, since the discovery of radio-activity.

The present paper is essentially mathematical and unsuitable for abstraction. Adopting the same constants as assumed by Perry and Heaviside, the number of years that have elapsed since the earth began to cool from its molten state is found to be $9{\cdot}02 \times 10^9$. [See also next Abs.] T. B.

933. *Symbolical Methods in the Theory of Conduction of Heat.* **T. J. I'a. Bromwich.** (Cambridge Phil. Soc., Proc. 20. pp. 411–427, Nov., 1921.)—The paper is divided into: (1) general consideration of a method for solving conduction of heat problems; (2) application of Heaviside's method to the problem of a sphere surrounded by a shell of different material; (3) numerical tests of the formula; (4) evaluation of certain symbolical expressions required in (1) and (2). The estimate made of the age of the earth ($9\cdot37 \times 10^9$ years) is not regarded as of importance, as it would be easy to estimate new values of K and k which would yield almost any value of t from 10^9 to 10^{10} years.

The paper is entirely mathematical. [See also preceding Abs.] T. B.

934. *Heat-Interchange between Solid Bodies and Fluids of Small Viscosity and Heat Conductivity.* **E. Pohlhausen.** (Zeits. Math. u. Mechanik, 1. pp. 115–121, April, 1921.)—The similarity in the case of a flowing liquid between heat conductivity and heat convection on the one hand and internal friction (" impulse " conductivity) and " impulse " convection on the other is shown in the differential equations developed in the paper. A relation between the heat interchange and the viscosity resistance can be inferred, which exists between a flowing liquid and a solid immersed in it. This was first done by Prandtl, who assumed the existence of sources and sinks in the liquid. Prandtl also dealt with the case of small fluid friction by simplifying the differential equations for this particular case. The author at Prandtl's suggestion deals with the case of small heat conductivity, and shows how the heat lost by a thin plate in a parallel stream of liquid can be obtained, as well as the temperature of the fluid and plate. The paper is entirely mathematical. T. B.

935. *Calculation of the Specific Heats of Gases.* II. **W. Herz.** (Zeits. Elektrochem. 27. pp. 474–475, Oct. 1, 1921.)—The author gives four further equations [Abs. 1790 (1921)] with the aid of which the differences of the specific heats at constant pressure and constant volume can be calculated. Examples are added. H. B.

936. *Electric Adiabatic Calorimeter; Determination of the Specific Heat of Solutions of Cadmium Sulphate.* **E. Cohen** and **A. L. T. Moesvelt.** (Zeits. phys. Chem. 95. pp. 305–327, Aug. 13, 1920.)—The calorimeter used in the researches on the normal Weston cell for the determination of the specific heat of cadmium sulphate solutions at 19° in concentrations containing from 1·89 up to 44·63 % (by weight) of $CdSO_4$ with an accuracy of 0·5 ‰, is of the type of the Holman and T. W. Richards's instrument, and differs mainly in the method of heating the jacket, which Cohen effects by using the water in the jacket as resistance. As the concentration of the salt solution increases as stated, its specific heat diminishes from 0·9763 to 0·5725. These values are in good agreement with those of Berthelot and of Thomsen. H. B.

937. *Thermal Stresses in Spherical Shells Concentrically Heated.* **C. H. Lees.** (Roy. Soc., Proc. 100. pp. 379–394, Jan. 2, 1922.)—It is pointed out that the circumstances producing high thermal stresses are present to an exceptional degree in metallurgical, pottery, and glass furnaces, and that in these cases disintegration of materials used in furnace construction is most marked. A theoretical investigation of the stress-strain-temperature effects in a spherical shell is made. The dilatation per cm.^{3}, α_θ of each elementary shell is regarded as divisible into: (1) a part $\bar{\alpha}$, equal to the mean dilatation for the whole shell; (2) a part, α'_θ, equal to the excess of the actual dilatation over that mean. The first part introduces no stresses ; the thermal stresses are all due to the second part. It is shown that the general problem of the stresses in a spherical shell, produced by change of temperature such that isothermal surfaces are concentric spheres, and by pressures applied to its surfaces resolves itself into the determination of the stresses and displacements due to the expansion α'_θ of each elementary shell above or below the mean $\bar{\alpha}$ for the whole shell, and the superposition on these of the displacements due to the mean expansion $\bar{\alpha}$ and of the stresses and displacements due to the pressures applied to the inner and outer surfaces of the expanded shell. A method of graphical representation of the mathematical results obtained is given. Variations of the results due to unsteady temperature distribution are discussed. An inspection made of fractured materials and of furnaces which have been in use supports the theories developed. The forms of the expressions for the stresses show that the stresses are proportional to the product of the dilatation of the material with rise of temperature and Young's modulus for the material. For materials for furnace walls this product should be as low as possible, and it is suggested that better success may attend the search for a material with a low dilatation with rise of temperature, *e.g.*, silica brick. A. B. C. L.

938. *The Vaporisation Coefficients of Solid and Liquid Mercury.* **M. Volmer** and **L. Estermann.** (Zeits. f. Physik, 7. 1. pp. 1–12, 1921.)—When a vapour at constant pressure is deposited on a cold surface, the temperature of which is so low that re-evaporation can be neglected, the max. velocity of deposition G (in gm. per sec. per cm.^{2}) is equal to the number of molecules falling on the surface. Hence $G = \frac{1}{4}ncm = \sqrt{(Mp/T)}/\sqrt{(2\pi R)}$, where m denotes the mass of a molecule, p = pressure of vapour (dynes/cm.^{2}), m = molar weight, T and R respectively the absolute temperature and gas constant. If a fraction α of the impinging molecules only is condensed and the remainder are reflected, we have $G = \alpha\sqrt{(Mp/T)}/\sqrt{(2\pi R)}$. If the condensate is at a temperature corresponding to the vapour pressure p, we have equilibrium, i.e., the velocity of evaporation is equal to the velocity of condensation. Hence for vaporisation in a vacuum we have $G = \alpha\sqrt{(Mp/T)}/\sqrt{(2\pi R)}$. These are Langmuir's expressions. Experiments made by Marcelin, Knudsen, and Bennewitz to determine α have not led to completely satisfactory results. Knudsen and Bennewitz concluded that $\alpha = 1$ in all cases, but researches of Grösse and Volmer on the formation of crystals show that for solids α must be less than unity. The author's experiments were designed to obtain further results covering a wide range of temperature, with the hope of settling the value of α. The remainder of the paper contains a full description with tables of results of two methods used to find the values of α.

In one method the velocity of evaporation was deduced from the rate of diminution of radius of the drop, and in another set of results (applicable to temperatures below 0°) the amount of deposited mercury is obtained from its electrical resistance.

In the other method the condensation and reflection at a solid mercury surface were determined by the help of an improved form of Knudsen's apparatus for the same purpose. The authors conclude that for liquid mercury α is unity and independent of the temperature, while for solid mercury α is less than unity, but the dependence on temperature is uncertain. Another paper on sulphur, phosphorus, etc., is promised, these having small values of α, besides being suited for determining the temperature effect. The experiments showed a close connection between the values of α and the degree of under-cooling. T. B.

939. *Gas Volume and Temperature; Law of Mewes.* **R. Mewes.** (Zeits. Sauerstoff u. Stickstoff Ind. 12. pp. 10–13, Feb., 1920.)—Continuing his investigations, the author points out that the ideal gas laws must be abandoned. Guy Lussac's law is only valid for nitrogen at atmospheric pressure. The author's own summation law also fails with increasing pressure; but the discrepancies are traced to surface condensation and mass attraction. The gas densities are best estimated by observing the change of vapour tension with decreasing temperature. H. B.

940. *Boiling-Point in the Kathode-Glow Vacuum and Critical Temperature.* **P. Walden.** (Zeits. anorg. Chem. 112. pp. 225–232, Sept. 14, 1920.)—Referring to the generalisations of Herz, van Laar, and others, and making use of the tables of Krafft and others for various organic compounds, the author shows that the relation between the boiling-point at 15 mm., T_{15}, and that in the vacuum of the kathode glow, T_0, is $T_{15} = 1{\cdot}22 \times T_0$, and the critical temperature is $T_k = 2{\cdot}54T_0$. For the metals K, Na, Ag, Cu, $T_{760} = 4{\cdot}55T_0/\log T_0$; for metals whose boiling-point in the kathode-glow vacuum is not known, the author introduces the temperature $T_{\text{vap.}}$ at which vaporisation begins in that vacuum. H. B.

941. *Theoretical Value of Sutherland's Constant in the Kinetic Theory of Gases.* **C. G. F. James.** (Cambridge Phil. Soc., Proc. 20. pp. 447–454, Nov., 1921.)—In any attempt to deduce, from observations on viscosity and diffusion of gases, the facts as to the nature of the intermolecular forces, it is necessary to find the theoretical relation that holds between the so-called Sutherland's constants and any assumed intermolecular force. It is assumed that the molecule behaves as a perfectly elastic sphere surrounded by a field of attractive force. This is in fact the only known model, capable of satisfactorily predicting the observed laws of variation with temperature of these quantities, at least at ordinary temperatures. The relations in question have been worked out by Chapman [Abs. 970 (1917)]. It appears, however, that the formulæ in question are affected by a certain error explained in the present paper. This mistake affects the relations between Sutherland's constant S for a single gas, and analogous quantities, and the potential of the intermolecular field. This, however, in no way affects the rest of his theory, or the numerical values of σ, the molecular diameter, obtained. These are in fact deduced directly from observed values of S. It is only when theoretical values of S become important that this mistake is of any significance. The theoretical determination of this constant is the subject of this paper, which is of a mathematical nature. It is known that with fair accuracy the relation between the viscosity μ of a single gas and the temperature T is, when T is sufficiently large, $\mu \propto T^{1/2}/(1+S/T)$, where S is Sutherland's constant, and can be calculated in terms of the forces in action. Thus, if $\phi(r)$ is the potential of the force between two molecules whose distance apart is r, Chapman's result was $S = \phi(\sigma)/3R$, R being the usual gas constant for one molecule $(1{\cdot}372 \times 10^{-6})$. The correct result is not so simple as this, and cannot be explained so generally. In the same way the coefficient of diffusion for a mixture of two gases satisfies a relation $D_{12} \propto T^{3/2}/(1 + S_{12}/T)$, where if $\sigma_{/12}$ denotes the mean of the two molecular diameters, $S_{12} = \lambda\phi(\sigma_{12})/R$, where λ is a number depending on the laws of force assumed. Chapman gives $\lambda = 1/2$ for all laws of force. The subject is discussed under the following heads: Approximations employed; Statement of the problem; Calculation of the correction in the angle χ; Viscosity of a single gas—general analysis; the Inverse power law; Calculation for the law of force; the Decrease of Sutherland's constant S for a given value of $\phi(\sigma)$; the Second-order terms; and Diffusion of a mixture of two gases. The following figures are given for the shell of constant force:

α	1·25	1·50	1·75	2	2·5	3	4
$RS_{12}/\phi(\sigma)$	0·153	0·208	0·243	0·268	0·303	0·327	0·358
α	5	6	7	8	9	10	
$RS_{12}/\phi(\sigma)$	0·378	0·393	0·404	0·413	0·420	0·425	

Chapman's value was 0·5 in all cases. It can be verified that this sequence tends to zero as α tends toward unity. A. E. G.

942. *The Theory of Gas Modification.* **H. Mache.** (Zeits. f. Physik, 5. 5 and 6, pp. 363–370, 1921.)—The equation of state of gases at very low temperatures is discussed with the aid of thermodynamics alone. The only assumption made is that for the modified gas, the pressure coefficient and the specific heat show the same dependence on temperature, these two quantities at a given density being proportional to one another. Gruneisen in 1908, from experiments on metals, had already deduced that the thermal coefficient of expansion and the specific heat at constant pressure (C_p) were nearly independent of temperature. This astonishing result he was able to establish on his theory of monatomic solid bodies, which was based on Mie's theory of the power law for the repulsion and attraction between atoms. We are concerned here with a law which strictly holds only at low temperatures. Gases show at low temperatures, with a diminution of rotational energy, the behaviour of monatomic gases, where at a given pressure this proportionality between coefficient of expansion and C_p holds also at very high temperatures. Strong support for the assumptions made are brought forward.

At first the state of aggregation is not considered, and the author seeks only what thermodynamics permits him to state for any body for which the relation considered holds. For the sake of simplicity in the equations a proportionality is assumed not between coefficient of expansion and C_p, but between pressure coefficient and C_v. For an unmodified monatomic gas both proportionalities are rigorously true. For a solid body neither the pressure coefficient $(\partial p/\partial T)_v$ nor C_v can be directly measured. However, from Nernst's theorem at very low temperatures it follows that proportionality exists between $(\partial v/\partial T)p$ and C_p and also between $(\partial p/\partial T)_v$ and C_v. Consequently $(\partial p/\partial T)_v = \psi C_v$, where ψ denotes a volume function only. The thermodynamical consequences of this assumption are followed out, as obtained in a different way by Gruneisen. It is found that the specific heat C_v is a function of T/θ, where θ is a pure volume function which can be immediately calculated from ψ. θ has the dimensions of temperature, and was called by Debye the "characteristic temperature " of the body. The case is then considered of a perfect gas, and especially of a monatomic one, and changes in adiabatics and isothermals at very low temperatures are traced. Finally a formula of Nernst's is discussed for vapours at very low temperatures, and a method suggested of finding C_p/C_v from observations of the isothermal compressibility. T. B.

943. *Gaseous Combustion at High Temperatures.* II. *Explosion of Hydrogen–Air and Carbon Monoxide–Air Mixtures.* **W. A. Bone** and **W. A. Haward.** (Roy. Soc., Proc. 100. pp. 67–84, Oct. 4, 1921.)—Haward was killed in the course of the experiments. Previous researches had shown that, whilst the affinity for oxygen of methane is at least 20 times greater than that of hydrogen, the time required for attaining the maximum pressure in the case of primary mixtures of $(CH_4 + O_2 + 4N_2)$ is from 5 to 8 times as long as in the case of $(2H_2 + O_2 + 4N_2)$; further, that in mixtures of $(H_4 + O_2 + xH_2$, where x ranges from 2 to 8) the mass influence of successive increases in x upon the oxygen distribution between the two gases is proportional to x^2, whilst in mixtures $(CH_4 + O_2 + xCO)$ it is proportional to x; and that in mixtures of $(2H_2 + O_2 + 4N_2)$ and of $(2CO + O_2 + 4N_2)$, which contain the combustible gas and oxygen in their combining proportions and which on explosion develop the same total energy, viz. 68·4 and 68·0 K.C.U. per gm.-molecule, it takes at least 10 times longer in the latter case than in the former to attain the maximum pressure. It thus appeared that the rate at which the potential energy of an explosive mixture is transferred into thermal energy as measured by the rise in pressure, is not primarily determined by the chemical affinity between oxygen and the combustible gas. Further experiments are hence made with a bomb of a capacity of 275 cm.^{3} provided with a Petavel manometer and a tuning-fork indicating within 0·005 sec. Of 52 experiments made with gases at an initial pressure of 50 atmos., 18 are selected. In mixtures $(2H_2 + O_2 + 4X_2$, where X = nitrogen, hydrogen, or oxygen) H or O is substituted for the diluent N. With N itself the pressure rises within about 0·005 sec. to 400 atmos., and then at once drops off slowly owing to cooling; the curves show no vibrations; the substitution of H or O for N made hardly any difference. The curves of $(2CO + O_2 + 4N_2)$ show a much (36 times) slower rise of pressure, and the pressure then remained steady for an appreciable time during which heat was still being liberated apparently; the cooling itself was also slower. Isothermic mixtures of $2(mH_2 + nCO) + O_2 + 4N_2$ (where m and n are variable, but $m + n = 1$) give curves strongly resembling the curves of hydrogen–air mixtures, so that the presence of as little as 1 per cent. of H in a CO–air mixture has a disproportionately large influence in accelerating the pressure rise. There are thus marked differences between the combustions of H and of CO, the latter being difficult to oxidise in flames. The presence of steam accelerates this combustion of CO (Dixon). It is suggested that in ordinary flames, CO cannot interact with undissociated O_2. When raised to a certain temperature, however, the undissociated O_2 molecule has its residual affinities sufficiently stimulated to seize upon two undissociated H_2 molecules forming the complex H_4O_2 which breaks down into steam, H_2 molecules, and O atoms; these nascent atoms of O would be reactive towards CO if continuously reproduced at sufficiently high temperature. In any case recent researches tend to prove that the relative combustion processes are not merely proportional to their heats of combination, irrespective of chemical characteristics and modes of combustion. H. B.

944. *Heats of Combustion and Energy of Dissociation.* I. *and* II. **A. v. Weinberg.** (Deut. Chem. Ges., Ber. 53B. pp. 1347–1353, and pp. 1519–1528, Sept. 18, 1920.)—A further exposition of the views expressed by the author in his papers on the kinetic benzene formula, partly now in reply to criticisms by Fajans. The following relations are found to hold approximately at 18° C.: (1) In saturated aliphatic hydrocarbons the energy of dissociation of a C—C bond is equal to that of a C—H bond, so that $Q_{CC} \simeq Q_{CH}$; this presumes that the energy required for the separation of two atoms (similar or dissimilar) is evenly distributed between the two atoms. (2) The absolute value of Q_{CH} is by 7·5 cals. greater than the energy of the dissociation of a hydrogen molecule, which is calculated after Franck, Knipping, and Krüger. (3) Molecular cohesive forces have not to be overcome in the combustion of solid carbon which practically only requires the provision of the energy of 4 carbon valencies. The absolute value for diamond or graphite is $2Q_{CC} + 1 \cdot 5$ cals.; if 96 cals. be adopted for the combustion of solid amorphous carbon, the latter would seem to behave during combustion like a gaseous saturated hydrocarbon; solid carbon would thus differ from all solid organic compounds, and the existence of liquid molecular carbon would be impossible. The heat of combustion of diamond being 94·5 cals., the difference of 1·5 cal. can only be explained on the supposition that the work of dissociation of diamond is greater than that of amorphous carbon. It is noteworthy, however, that the heat of combustion of benzene does not agree with Debye and Scherrer's X-ray studies. (4) In the oxidation of CO to CO_2 the energy of dissociation of the two so-called unsaturated valencies is equal to Q_{CC}.

Thus it would appear that, at 18° C., the five most common linkings in organic compounds are almost equally stable:

$$Q_{CC} \simeq Q_{CH} \simeq Q_{C-O} \simeq Q_{NH} \simeq Q_{N-N}.$$

The author extends his calculations to other links, C≡N, N≡N, Cl—O, etc., in a great variety of compounds. As regards Q_{HCl}, he confirms Born and Haber, that the energy of dissociation is equal to the electronic affinity of the chlorine. H. B.

945. *The Numerical Value of the Gas Constant.* **F. Henning.** (Zeits. f. Physik, 6. 1. pp. 69–72, 1921. From the Physikal.-Techn. Reichsanstalt.)—Recent determinations of various physical constants—especially from experiments at the Reichsanstalt—have rendered necessary a recalculation of R, the gas constant. R may be defined by the equation $R = V_n/T_0$, where V_n is the normal molecular volume of an ideal gas at the ice-point, and under the pressure of a normal atmosphere. That is, $V_n = \left\{Mpgv(p\,;T)\right\}/0 \cdot 76 \times 980 \cdot 665[1 + \beta t + k_0 p]$, where β is the mean coefficient of expansion of the gas between 0° and t° at the ice-point pressure $p_0 = 273p/T$, and $k_0 = [d(pv)/dp]_{T_0}/p_0 v(p_0\,;T_0)$, the coefficient of compressibility of the gas at 0° and small pressure increase. The gas chosen must be oxygen ($M = 32 \cdot 000$), as the physical constants of the other gases are not known with sufficient accuracy. The density of O is taken as $\rho(0{\cdot}76\ ;\ T_0) = 1{\cdot}4291$ gm. per litre with $g = 980{\cdot}665$. The value of k_0 is $-(130 \pm 15)10^{-5}$ and $V_n = 32/1{\cdot}4291 \times 0{\cdot}99901 = 22{\cdot}414$ litre. The abs. temp. of the ice-point is 273·20° (Henning and Heuse, *ibid.*, 1921). This gives $R = 0{\cdot}08204 \pm 0{\cdot}00003$ litre-atmo./deg. mol. or $8{\cdot}313 \pm 0{\cdot}003 \times 10^7$ erg/deg. mol., or $8{\cdot}309 \pm 0{\cdot}003$ intern. Joule/deg. mol. Finally taking 1 $\text{cal.}_{15} = 4{\cdot}1842$ intern. Joule [Jaeger and Steinwehr, Abs. 884 (1921)], $R = 1{\cdot}986 \pm 0{\cdot}001$ cal._{15}/deg. mol. T. B.

946. *Theoretical Determination of the Chemical Constant of a Monatomic Gas.* **E. Brody.** (Zeits. f. Physik, 6. 2. pp. 79–83, 1921.)—The application of the quantum theory to the consideration of an ideal gas has not been very successful hitherto, as the foundations of the theory were until recently very uncertain when applied to systems with several degrees of freedom. The problem has been attacked by Planck on the basis of his second theory, and by Scherrer on that of Planck's first theory.

The problem of the determination of the chemical constant of an ideal monatomic gas is approached by the present author on the basis of Planck's first theory. The paper consists of two parts: (1) Quantum theory; (2) Statistical considerations (probability). Starting with the Boltzmann equation $S = k \log W$, where S is the entropy of that state whose probability is W, and k is the Boltzmann constant, it is deduced that the chemical constant of an ideal monatomic gas is

$$C = \log \left\{ (2\pi m)^{3/2} \,.\, k^{5/2}/h^3 \right\},$$

m being the atomic mass and h Planck's constant. T. B.

947. *Determination of "h" by Means of X-Rays.* **W. Duane, H. H. Palmer,** and **Chi-Sun Yeh.** (Nat. Acad. Sci., Proc. 7. pp. 237–242, Aug., 1921. Phys. Rev. 18. pp. 98–99, Aug., 1921.)—In its application to X-rays the quantum law is expressed by the equation $Ve = h\nu$, where V is the max. difference of potential in the X-ray tube, e the charge on each electron, ν the frequency of vibration corresponding to the short-wave-length limit of the spectrum, and h is Planck's action constant. The object of the present investigation is to increase the accuracy of determination of h from the above relation. For details of the experimental method the original paper should be consulted. The final value of h obtained is: $h = (6{\cdot}6556 \pm 0{\cdot}009) \times 10^{-27}$. A. B. W.

948. *A Simple Improvement of the Law of Corresponding States.* **L. Schames.** (Phys. Zeits. 22. pp. 644–645, Dec. 1, 1921. Paper read at the Deut. Physikertag., Jena, Sept., 1921.)—Developing considerations first indicated in the papers of Abs. 515 (1917) and 319 (1919), the author points out that the law of corresponding states cannot hold strictly because the a in the equation of state is an individual variable, varying to an unknown extent. The introduction of further constants cannot be of much service. Instead of selecting the reduction terms T_x, p_x, v_x, referring to the critical point, and thus to a very limited range, we can, however, adopt other deductive terms from Avogadro's state, $T_x v_0/v_x$, v_0, and RT_x/v_x (for the pressure). Then helium and hydrogen, which deviate from other gases with respect to van der Waals' equation, fall more in line with air, oxygen, nitrogen, C_2H_4, and CO_2, and the range is considerably enlarged. Curves are given. H. B.

949. *Generalised Corrections for the Equation of State ; Special Equation of State for Hydrogen.* **L. Schames.** (Phys. Zeits. 22. pp. 630–634, Nov. 1 and 15, 1921. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—The essential improvements hitherto introduced into the van der Waals equation of state, $(v - b)(p + a/v^2) = RT$, consist in that the volume correction b, and the attraction magnitude a, are regarded as functions of the state. These theoretical investigations have been based on the van der Waals assumption that the molecules are perfectly rigid spheres, and that b is only a volume function determined from a series, $b = b_A[1 + b_1(b_A/v) + b_2(b_A/v)^2 + \ldots]$, where the index A characterises the Avogadro state. This conception of rigidity is not now regarded as strictly valid in view of the electrical theory concerning the structure of matter and the experimental data for very high temperatures. This rigidity conception, however, may still be assumed for most purposes and is adopted here, necessitating therefore a special discussion for extremely high temperatures.

Section 1 derives the coefficients b from the impact function, $\phi(v) = v/(v - b) = 1 + \phi_1(b_A/v) + \phi_2(b_A/v)^2 + \ldots$. Further coefficients beyond ϕ_3 are then calculated by another method to avoid the almost insuperable difficulties which accompany the first process. Section 2 deals with the attraction magnitude a, and its connection with the internal energy U is first discussed. If the thermodynamic attraction $\mathfrak{a}$ be defined as $\mathfrak{a} = \partial U/\partial v . v^2 = [T(\partial p/\partial T)v - p]v^2$, then it has been shown that $a = T/[T, \propto]\mathfrak{a}d(1/T)$; it is now proved that this is valid only on the assumption of rigidity. The temperature dependence of a in the Avogadro state has a simple relationship with the virial coefficient B, and Keesom has contributed the further assumption that the molecules are electrically rigid tetrapoles, thereby developing the temperature dependence of B as a series. For low temperatures this series converges only slowly ; for high temperatures the assumption of electrical rigidity is unreliable, since the tetrapoles become much more electrically polarisable and their mutual attraction greater than that given by Keesom. For the highest temperatures the assumption of mechanical rigidity is still more untenable, and in consequence the simple connection between a and $\mathfrak{a}$ is no longer valid, a new function being developed. Section 3 deals with b and a_A, since the assumption of the former as a volume function and the latter as a temperature function no longer suffices. Deviations at low temperatures are ascribed to a quantum effect, and will be dealt with later. H. H. Ho.

950. *The Theorem of Corresponding States and the Quantum Theory of Gases and Liquids.* **A. Byk.** (Ann. d. Physik, 66. 3. pp. 157–205, Dec. 6, 1921.)—This paper is a more complete account of the preliminary version given elsewhere recently under the same title [see Abs. 1112 (1921)]. It commences with a discussion of the theorem of corresponding states and the special position of substances of low critical temperature. The quantum theory of Planck, which was established to provide an explanation of thermal radiation, has taken a direction which finds its characteristic expression in the Bohr atomic model. So far as application has been made to the theory of aggregate states, it has provided only scanty results for liquids and gases as compared with those for solid bodies. Certain consequences for the latter have been deduced by Einstein respecting specific heats from the analogy of swinging atoms with Planck's oscillators, and Debye has extended this line of attack to give definite results. Attempts to extend this method of special oscillations to the fluid state appear, however, somewhat artificial, and have led to scarcely any further results than the establishment of the main principle of the quantum theory to this region, namely, the expression for the entropy of the ideal dilute gas at high temperatures, with the accessory chemical constants. Planck, by his subdivision of the phase space into definite finite elements of probability, has given a more general method for the quantum theoretical treatment of molecular systems than that of special oscillations. This has not hitherto been applied further than ideal gases, and it is not easy to extend the Planck structure theory of phase space to the fluid state generally, where the finite character of the molecules and the van der Waals attraction forces have to be taken into account. It is shown, however, that without such special and so, to a certain degree, arbitrary assumptions, the general basis given by Planck of the molecular quantum mechanics for the thermodynamics of highly compressed gases and liquids leads to valuable consequences accessible to experimental test. For molecular systems, which satisfy the condition of mechanical similarity, K. Onnes has shown that classical mechanics leads to the van der Waals theorem of corresponding states. This appears as a limiting case for substances possessing high critical temperatures, and in general the deviations from this theorem are greater the lower the critical temperature, and attain the maximum with very low-boiling gases such as helium. The question arises whether these deviations are of such a kind that the whole theory has to be abandoned, or whether it may be possible to obtain an explanation by modification or further development. It is shown that if the classical basis be replaced by a quantum mechanism, the theory may be extended to include these low-temperature deviations. Accordingly a quantum generalisation of the theory of corresponding states is discussed at length.

The principle of mechanical similarity is first considered together with the thermodynamics of a chemically monatomic and compressed gas. The following expression is deduced: The reduced free energy of a group of chemically unit substances, whose thermodynamic states respecting their phase orbits can be expressed by mechanically similar molecular systems, is found to be a universal function of the reduced volume, temperature, and active quantum of the substance concerned. This proposition is designated the quantum theorem of corresponding states. The influence of the molecular weight and the number of atoms in the molecule upon the value of the thermodynamic quasi-invariants is noted and the conclusions of Nernst and Einstein confirmed, that substances with very small molecules show appreciable deviation from the law of corresponding states. It is very noteworthy that the quantum theory of corresponding states in contrast to the classical, not only includes the equation of state (the pressure), the negative partial differential coefficients of the free energy by the volume, but also the entropy and the negative partial differentials of the free energy by the temperature. This is because reference is made to the characteristic thermodynamic function of the free energy itself, and not alone to its volume coefficients as in the classical theory. The quantum theory is next applied to the equations of state for saturation. A large amount of data is tabulated in this section. Following this comes the calculation of vapour-pressure equations and of boiling-points for 42 substances ranging from helium to tin tetrachloride. A comprehensive table of references to work on this subject is also included. The next calculation is that of vapour volume equations and of volumes at the boiling-point. Tables are included of quasi-invariants in homologous series and for isomers respectively. The critical coefficients are finally evaluated.

The concluding section deals with the thermodynamics of gases and liquids and the quantum theory; it includes the treatment of absolute dimensions and the principle of relativity. In addition to the saturation equations, the following thermodynamic relationships may be treated by reduced equations in the sense of the classical theorem of corresponding states with w as individual parameter which disappears for small values of w:—The characteristic thermodynamic function of a monatomic gas according to the Planck structure theory of phase space; the empirical equation of state of K. Onnes; the modification of the theorem of corresponding states by K. Meyer; the equations of state for perfect gases by Avogadro, Berthelot, and Wohl; the quantum equations of state for non-perfect gases by Sackur, Nernst, and Keesom; the Boyle-temperature effect; the inversion temperature of the Joule-Kelvin effect; the critical vapour-pressure coefficient; the revised Trouton rule for heats of evaporation; and the entropy of ideal monatomic gases. The theorem may likewise be applied to the coefficient of internal friction by Reinganum and Nernst; the temperature-coefficient of molecular surface energy by Eötvös; and the reduced molecular refraction by Guye. The thermodynamics of gases and liquids appears to be in the same position as the thermodynamics of vacuum (thermal radiation) were on the introduction of the Wien displacement law. The results obtained in contrast to Tolman's postulated relativity of magnitude lead to the conception that while motion is relative, its magnitude is absolute. From such abstract propositions physical significance is obtained first by a precise mathematical formulation and then by concrete applications. The former gives the quantum theory of corresponding states in the form of an equation which can be generalised, the latter results in the physical thermodynamics of the liquid state. H. H. Ho.

951. *The Thermodynamic Theory of van der Waals, the Capillary Layer of Bakker, and the Isothermal of J. Thomson.* **G. Bakker.** (Ann. d. Physik, 65. 6. pp. 507–519, Aug. 30, 1921.)—The author deals with what he considers misunderstandings of J. Thomson's isothermal between liquid and vapour by Minkowski, van der Waals, and Jellinek. For a point outside the capillary layer the pressure p_N (equal to vapour pressure) at right angles to the boundary has to be distinguished from the pressure p_T in the direction of the boundary, as pointed out by the author in Abs. 803 (1920). We have to consider, not the different points in a single capillary layer, but the conditions in all the concentric spherical capillary layers which are possible at the particular temperature. H. B.

952. *The Refraction of Adiabatics: Special Study of Refraction at Low Temperatures.* **G. Bruhat.** (J. de Physique et le Radium, 2. pp. 287–296, Sept., 1921.)—Section 1 considers general formulæ. The equation of state for the homogeneous fluid is taken as $p = f(v, T)$, and in the various formulæ p stands for pressure, T the absolute temperature, L the latent heat of vaporisation, u and u' the specific volumes of liquid and vapour, respectively, and m and m' the specific heats at constant volume and pressure, v the total volume of unit fluid mass, and x the ratio of the mass of vapour to the total mass. From a point on the saturation curve, two adiabatic transformations are considered, one without condensation relative to the pure vapour, and the other with condensation relative to the mixture of vapour and liquid. From the various classical formulæ, the slope of the adiabatic in the second transformation is found to be $\cot\alpha = dv/dp = -(1/dp/d\mathrm{T})^2[\mathrm{J}c'/\mathrm{T} - \partial f/\partial v(\partial u'/\partial\mathrm{T})^2]$. This formula shows that dv/dp is always negative. If β be the angle of the adiabatic in the first transformation with the v axis in Clapeyron's representation, then the refraction of the adiabatic is given by

$$\cot\beta - \cot\alpha = -\frac{\partial f}{\partial v}\cdot\frac{(\mathrm{J}c'/\mathrm{T} + \partial f/\partial\mathrm{T}.du'/d\mathrm{T})^2}{(dp/d\mathrm{T})^2[(\partial f/\partial\mathrm{T})^2 - \mathrm{J}c'/\mathrm{T}\,.\,\partial f/\partial v]} = \frac{\mathrm{J}}{\mathrm{T}}\cdot\frac{m'^2}{c'(dp/d\mathrm{T})^2}.$$

Since c' is essentially positive, this formula shows that in absolute value the adiabatic of the gas always makes a smaller angle with the pressure axis than the adiabatic of the mixture. Raveau has shown this to be a consequence of the general laws of equilibrium displacement, and his elegant geometrical demonstration is reproduced here. Section 2 deals with the values of m' and L at low temperatures. Data are given for sulphur dioxide, chloroform, and benzene. It is shown that for temperatures sufficiently low m' is negative, and increases indefinitely in absolute value when T tends towards 0. For temperatures sufficiently elevated, the quantity $\phi(\mathrm{T})$ should become equal or greater than L_0, and the specific heat m' should become positive. The existence of the lower inversion point is then explained by the formula:

$$m' = (-\mathrm{L}_0 + \mathrm{C'T} - \int_0^{\mathrm{T}}\mathrm{C}'d\mathrm{T} + \int_0^{\mathrm{T}}\mathrm{C}d\mathrm{T})/\mathrm{T}.$$

It is equally clear why, for substances such as water, which have an enhanced value of the heat of vaporisation, m' remains constantly negative. Section 3 considers the refraction of the adiabatics at very low temperatures. It is shown that the adiabatic of the mixture and the isothermal of the gas make equal angles with the curve of saturation, and that these angles are infinitesimals of the order of T with respect to the angles which the adiabatic of the gas and the isothermal of the mixture make with the saturation curve. In Section 4 various curves are drawn for very low temperatures. It is shown that as T tends towards zero the entropy of the saturated vapour increases indefinitely by positive values, also that in an adiabatic expansion liquefaction tends to become complete when the volume increases indefinitely and the temperature tends towards absolute zero. The paper is mathematical throughout.

H. H. Ho.

953. *The van der Waals Correction for Cohesion Forces.* **W. H. Keesom.** (Phys. Zeits. 22. pp. 643–644, Dec. 1, 1921.)—The present note contains an extended version of a previous paper [see Abs. 158 (1922)] with respect to the calculation of the tetrapole moment of the gases then considered, this having been necessitated by the recent communication of Debye [see Abs. 279 (1922)] on molecular forces and their electrical significance. The author cannot agree with Debye's mode of employing the average reduced equation of state. A brief discussion is given of the circumstance pointed out by K. Onnes that the reduced equation of state is in no case in exact accord with reality. For this the law of corresponding states should be exactly obeyed at the critical point, which is by no means the case for hydrogen in comparison with nitrogen and oxygen. Complete discussion is deferred to a later communication, and the remainder of the paper is devoted to the correction of a mistake in the earlier work. H. H. Ho.

954. *A Method of Evaluating Exactly the Equation of State for any given Liquid or Gas.* **C. W. Oseen.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 15. No. 3. pp. 1–12, 1921.)—Reference is first made to the mathematical work of Mittag-Leffler and its extension by Koch. The object of the present paper is then to show how a simple application of their results suffices for the derivation of a solution to the problem of finding the equation of state of any given liquid or gas, whose atoms interact with given forces. This solution is both mathematically exact and physically useful, and for simplicity a monatomic gas or fluid has been chosen. The author concludes that the hypothesis of molecular disorder is invalid. If the function W and the entropy S be determined as a function of the quantities which characterise a state of the system considered, then these quantities are to be so evaluated that S has its greatest possible value. By means of thermodynamic relations, the equation of state may be determined. It can be shown directly from the entropy, without application of the equation of state, that a van der Waals gas under certain conditions must divide into two phases whereby S possesses its maximum value. H. H. Ho.

955. *Isotopy and the Gibbs Paradox.* **E. Schrödinger.** (Zeits. f. Physik, 5. 2 and 3. pp. 163–166, 1921.)—Although the principal thermodynamic diversity of isotopes is unquestionable [see Abs. 488 (1916)], yet we are inclined to conclude this diversity to be very slight, especially in view of the great experimental difficulties which stand in the way of actual isotope separation by physical methods. This appears in a proof set forth by Fajans for the gaining of work from the process of mixing two isotopes, whereby the amount of work so gained is proportional to the magnitude of the atomic weight difference and decreases with it. The present author now investigates the mixture of two chemically indifferent gases under isothermally reversible conditions in order to find the total amount of work which can be gained therefrom. Here a finite difference in molecular weight occurs, and the amount of work stands in no relationship with the magnitude of this difference, and for chemically different gases may be easily found from elementary thermodynamic considerations. No semi-permeable walls are used, since their existence is unnecessary for isotopes, but solely an extensible homogeneous gravitational field. The results are then satisfactorily applied to the case of isotopes. An alternative thermodynamical consideration is based on the chemical constants, where differences may arise which depend in continuous manner on the atomic weight difference. When the isotopic gases are polyatomic, then the transition from thermal monatomic into the normal state has to be carried out in another way on account of the difference in moments of inertia. Gibbs and Boltzmann, in order to explain on dynamic grounds the action of a semi-permeable partition, have introduced a field of force which acts on one kind of molecule but not on the other, but the author claims novelty in his introduction of a spacially extensible force-field which acts preferentially on one of the molecules. H. H. Ho.

SOUND.

956. *The Perception of Sound Direction.* **A. Stefanini.** (N. Cimento, 23. pp. 5–30, Jan., 1922.)—It was long thought that the faculty of localising a sound is based on the difference in the intensity with which it is perceived by the two ears. Doubtless this difference assists the judgment, but this explanation appears to be in some cases insufficient, and phase difference is supposed to intervene. A critical examination of the experiments made by former investigators shows that the results arrived at are inconclusive and often contradictory. The author's own experiments seem to point to the cause of localisation being difference of intensity and not of time. He is able to assert that a difference of a few centimetres in the distance travelled by the sonorous impulse is sufficient to cause a perceptible variation in the intensity of a sound, and that therefore the effect ascribed to phase difference may well be due to a difference of intensity. He is of opinion that many of the results hitherto obtained have been vitiated by resonance phenomena in the interior of the tube, which shows how untrustworthy are the india-rubber tubes used in these researches. E. F.

957. *A New Tone Generator and Sound Receiver.* **C. W. Hewlett.** (Phys. Rev. 19. pp. 52–60, Jan., 1922.)—(1) *Construction and Operation.*—The instrument consists of a thin, non-magnetic, metallic diaphragm between two flat coils through which a constant direct current I_0 flows in such a way as to produce a radial magnetic field in the diaphragm; then when a simple harmonic alternating current I of the frequency $\omega/2\pi$ is superposed upon the direct current, circular currents are induced in the diaphragm, which thereupon is acted upon by a simple harmonic electrodynamic force and vibrates with the frequency of the alternating current. For low frequencies the electrodynamic force is approximately proportional to $\omega I_0 I \sin(\omega t + \theta)$ and the amplitude of vibration is approximately proportional to $I_0 I \omega$. The absence of overtones is due to the absence of ferromagnetic material, and to the fact that the radial magnetic field is constant. The aperiodicity of the diaphragm renders the calculation of the performance of the instrument practicable, and eliminates distortion, due to resonance, in the waveform of the emitted sound when the instrument is excited by a complex alternating current. When used as a generator of pure tones, the coils were connected in the circuit of a thermionic oscillator whose frequency could be varied from 500 to 25,000 vibrations per sec. When used as a receiver of sound, the current generated in the coils by the motion of the diaphragm is fed into a thermionic amplifier. (2) *Quantitative Study of the Performance.*—The distribution of the magnetic field between the coils was determined experimentally; the diaphragm current equations were deduced and solved for a particular case; the forces on various parts of the diaphragm were calculated, and thence the amplitude of vibration and the sound-energy output. With an Al diaphragm 0·0025 cm. thick and 10 cm. in diam., a direct current of 1 amp., an alternating current of 0·085 amp., and a frequency of $10^5/2\pi$, these were respectively 7×10^{-7} cm., and 9 ergs per sec. By increasing both direct and alternating currents five-fold, the output could be increased over six hundred-fold. Measurements of the amplitude for various frequencies agreed well with the calculated values. (3) *Applications of the Instrument.*—Since it gives a pure tone of constant and measurable pitch and intensity over a wide range, it would serve as a *precision source of sound*, useful both for research and lecture purposes. When used as a *telephone receiver and transmitter*, actual tests have shown that the reproduction of sound is remarkably faithful. AUTHOR.

958. *Whispering Gallery Phenomena at St. Paul's Cathedral.* **C. V. Raman** and **G. A. Sutherland.** (Nature, 108. p. 42, Sept. 8, 1921.)—The curious whispering-gallery effects observed under the dome of St. Paul's Cathedral have been explained by the late Lord Rayleigh as due to the curvilinear propagation of sound, the waves which proceed from a source placed close to the wall of the gallery clinging to its surface and creeping tangentially along it. This view was developed mathematically (Scientific Papers, vol. v. p. 607) and the following conclusions reached :—(*a*) The sound-waves travel in an arrow belt skirting the wall, the thickness of this belt decreasing with the wave-length ; (*b*) in this belt the intensity is a maximum near the wall and decreases rapidly and continuously as we proceed radially away from it ; (*c*) the intensity does not fluctuate markedly as we proceed circumferentially parallel to the wall.

The experiments of the present authors confirm the conclusions given under (*a*), but it is found that (*b*) and (*c*) are not in accordance with the actual facts. There are fluctuations of intensity, both radially and circumferentially. These were demonstrated by a high-pitched source and a sensitive flame. The authors hope shortly to revise the theory on the basis of these experiments. E. H. B.

959. *Sound Waves from Air Screws.* **L. Prandtl.** (Zeits. techn. Physik, 2. 9. pp. 244–245, 1921.)—Referring to previous work by Waetzmann [see Abs. 1916, 1917 (1921)], the author states that a note is produced by the two impulses received at an observer's ear, (*a*) directly from the screw and (*b*) after reflection from the surface of the earth, the frequency being given by the expression $c/2h \cos \phi$, where c is the velocity of sound, ϕ the angular distance of the machine from the zenith, and h the height of the observer's ear from the ground. Since two impulses give rise to a recognisable note, the rise in frequency as the machine approaches the zenith is clearly distinguishable, as well as that produced by a rapid alteration in h (*e.g.*, by bending down). This note is not improved by the use of a resonator, since it consists of two impulses only. The author goes on to describe experiments conducted with air-screws in an aerodynamics laboratory, with the screw operating (*a*) in free air and (*b*) in a wind-tunnel. J. W. T. W.

960. *Intensity of Sound and Atmospheric Conditions in Switzerland in Winter.* **Mme. Bieler-Butticaz.** (Arch. des Sciences, 3. pp. 548–550, Sept.–Oct., 1921. Paper read before the Soc. Suisse de Physique.)—Contains some brief notes on the composition and duration of the sound accompanying the striking of a church clock at Sépey (1050 m.) as observed at a point 60 metres away. The observations are confined to calm winter days. On occasions without cloud the sound dies out more rapidly by day than by night, and at night the duration is greater the higher the barometric pressure, while it decreases markedly with increased temperature and slightly with increased humidity. Fog, however, appears to have little effect, but falling snow diminishes the duration considerably and rain has the same effect though less marked. . M. A. G.

961. *"Light Body" Hydrophones and Directional Properties of Microphones.* **A. B. Wood** and **F. B. Young.** (Roy. Soc., Proc. 100. pp. 252–260, Dec. 1, 1921.)—Various forms of hydrophones were tested in the light of theory supplied by H. Lamb, the salient facts as to the production of a practical "light body" (i.e., lighter than water) directional hydrophone being as follows. Assuming the minimum density consistent with rigidity to be 0·25, the sensitivity coefficient may vary with the elongation from 2·0 for spherical shape to 3·8 for ten diameters long. The variation is less for higher densities. The max. direction ratio due to elongation is about 2·3 under practical conditions. This is negligible compared with the direction ratio obtainable from a well-mounted microphone. Hence it appears that little advantage is gained from adhering to the ellipsoidal form, whilst a sphere has the advantages of greater compactness and greater rigidity. E. H. B.

962. *Acoustic Disturbances Produced by Small Bodies in Plane Waves Transmitted through Water, with Special Reference to the Single-Plate Direction Finder.* **A. B. Wood** and **F. B. Young.** (Roy. Soc., Proc. 100. pp. 261–288, Dec. 1, 1921.)—The experiments here described were carried out between Oct. 1916 and Feb. 1917 on the Cullaloe Reservoir, near Aberdare, under the direction of W. H. Bragg, with the object of elucidating the action of the "single-plate direction finder" and "baffle." By means of a pair of miniature exploring hydrophones, the acoustic field was plotted around a number of discs placed in the path of plane waves propagated through the water of the reservoir, which is so large that reflections from the sides could be disregarded.

The characteristics displayed by the charts varied according as the discs were solid or contained air cavities. The *solid* bodies created comparatively slight disturbances in the sound waves, no variations of pressure amplitude being perceptible. The *hollow* bodies created very pronounced disturbances of direction, amplitude of displacement, and pressure amplitude. Very small air cavities produced marked effects.

The lead-wood baffle plate of the direction finder showed pronounced hollow-body characteristics, and from experiments made with "streamine" baffle plates containing slight air films, it was concluded that the air film between the lead and the wood constitutes the essential part of the baffle, the mass of the baffle plate being of minor importance. E. H. B.

963. *Acoustical Vibrator.* **H. Gerdien.** (Phys. Zeits. 22. pp. 679–683, Dec. 15, 1921. Paper read at the Deut. Physikertag, Jena, Sept., 1921. Zeits. techn. Physik, 3. 2. pp. 40–44, 1922.)—Describes with nine figures an acoustical vibrator consisting of a diaphragm clamped all round and electromagnetically actuated. E. H. B.

964. *Directed Hearing.* **W. Kunze.** (Phys. Zeits. 22. pp. 649–652, Dec. 1, 1921. Zeits. techn. Physik, 3. 2. pp. 48–49, 1922. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—A review of the subject of perception of sound direction and the work of the various investigators. It is pointed out that if the head is immersed in water, when a source of sound is moved through 180° from 90° on the right to 90° on the left, the impression is received that the source moves only from about 20° on the right to 20° on the left. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

965. ***Quantum Relation in Maxwell's Electromagnetic Theory of Light.*** **S. Ray.** (Zeits. f. Physik, 8. 2. pp. 142–144, 1921.)—Applying the theory of dimensions and considering the energy emitted per sec. by a light-wave, it is shown that Planck's constant, h, is equal or proportional to $\pi^2 M_0 c^2 A_0^2/\lambda_0^2$, the various symbols having the significance customary in wave motion. On Bohr's theory, this proportionality follows, provided the frequency of the pulses emitted is equal to that of the oscillations.

J. S. G. T.

966. *Electrodynamics in a Weak Gravitational Field.* **W. Alexandrow.** (Phys. Zeits. 22. pp. 593–601, Nov. 1 and 15, 1921. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—In a previous communication [Abs. 176 (1922)] the author has investigated the case of electrostatics in a weak non-static gravitational field and applied the results to some real special gravitational fields. The present paper investigates the most generalised problem of electrodynamics in a weak gravitational field. Expressed in vector form, the electrodynamic field equations have a special form which may appear as polarisation and magnetisation streams in the gravitational free space. The results should be capable of application to the propagation of plane electromagnetic waves in a reference system rotating in Galilean space, and in the gravitational field of a rotating spherical mass. This problem is reserved, however, for a later communication, and the present paper deals with the case of the static gravitational field. Here the purely electrodynamic derivation of the Einstein ray displacement is obtained, as also the following physical conception of the curvature of rays in the gravitational field:—Empty space (ether) is not only capable of the Faraday–Maxwell state of tension (as in the special theory of relativity), but also of polarisation and magnetisation (the result of the gravitational theory on the basis of general relativity). The Newtonian gravitational potential enters essentially as the electrical or magnetic susceptibility factor.

Section 1 of the paper deals with the extension of the previous publication and includes supplementary matter. Section 2 considers the electromagnetic field of the stationary conduction current in the weak gravitational field. Section 3 investigates the electromagnetic field of any given current and charge in the weak gravitational field. Section 4 contains the vectorial forms of the electromagnetic equations in the weak field and *in vacuo*.

The paper is mathematical throughout. H. H. Ho.

967. *Velocity of Waves Propagated along Faraday Lines of Force.* **S. Ray.** (Zeits. f. Physik, 8. 2. pp. 112–115, 1921.)—In the deduction of the velocity of propagation of an electromagnetic disturbance along a Faraday line of force from analogy with the propagation of a disturbance along a stretched string, the author corrects for the angle between the direction of the tube of force in its disturbed position and the direction of propagation of the disturbance. The resulting velocity of propagation is found to be equal to $(1 + k)^{1/4}/\sqrt{(\mu\epsilon)}$, when μ and ϵ are respectively the permeability and specific inductive capacity of the medium, and k is $4\pi^2a^2/\lambda^2$, where a is the amplitude and λ the wave-length of the disturbance. In the case of spherical waves for which $a = \sigma/r$, the disturbance is propagated to a distance r in time t given by $r - c_0t = \pi^2\sigma/2\lambda$, a relation which is applied to explain the well-known fact in physical optics that the secondary wavelets are advanced one-quarter of a period. It is pointed out that in Bohr's theory, the source of a light-wave is of finite dimensions, and the author suggests that $\sqrt{\sigma}$ may denote the distance of the orbit from the centre thereof. J. S. G. T.

968. *An Experiment on Electromagnetic Induction and Relative Motion.* **W. F. G. Swann.** (Phys. Rev. 19. pp. 38–51, Jan., 1922.)—*Charging Effect of the Rotation of an Iron Sphere in a Uniform Magnetic Field.*—The electromagnetic theory of this effect among others was developed by the author in a former paper. The answer which the theory gives is perfectly definite, but the nature of the problem is such that one who is accustomed to think in terms of moving lines of force may be uncertain as to the proper basis of attack and may even, quite plausibly, arrive at a result one-third as great as it should be. Therefore *an experimental verification of the theoretical formula* seemed worth while carrying out. It was found that when an iron sphere with a radius of 3·17 cm. was rotated at rates ranging from 3250 to 6430 r.p.m., in a magnetic field ranging from 3930 to 6070 gauss, the changes of potential of an insulated copper shell surrounding the iron sphere, which were observed when the magnetic field was reversed, ranged from 0·0114 to 0·0359 volt, while the corresponding calculated values ranged from 0·0116 to 0·0353 volt. In view of the experimental difficulties the fact that the average difference between observed and calculated changes of potentials for the seventeen sets of readings is only 1·7 % is considered a satisfactory verification of the theory. AUTHOR.

969. *Theory of the Dielectric Constants of Diatomic Dipole Gases.* **W. Pauli, Jr.** (Zeits. f. Physik, 6. 5 and 6. pp. 319–327, 1921.)—Both Langevin's formula for the susceptibility of a paramagnetic substance and Debye's formula for the dielectric constant of a dipole molecule contain a numerical factor of 1/3. Previous work by the author has shown that the quantum theory introduces a factor other than 1/3 in the Langevin formula [Abs. 532 (1921)], and the present paper calculates the numerical factor required by the quantum theory for the Debye formula for a diatomic dipole molecule. The value obtained for this factor is 1·5367. It is suggested that an experimental determination of the dependence on temperature of the dielectric constants of the hydrogen-halogen compounds would furnish data for deciding whether the classical or the quantum theory formula is the correct one. A. W.

970. *Motion of Electrons in Gases.* **J. S. Townsend and V. A. Bailey.** (Phil. Mag. 42. pp. 873–891, Dec., 1921.)—Gives a brief account of a method of determining electron velocities and of the application of the results to the determination of some properties of the molecules of gases. Results are included of a large number of experiments which have recently been made on the motion of electrons in hydrogen, nitrogen, and oxygen, with ranges of forces and pressures similar to those used in earlier experiments with air. A. B. W.

971. *Tensor Notation in Electromagnetic Theory.* **L. Bloch.** (Rev. Gén. d'Él. 10. pp. 507–513, Oct. 15, and pp. 755–759, Nov. 26, 1921.)—The author reminds us that the modern relativity theory has emerged from the systematic analysis of electromagnetic theory, in the course of which the latter has been greatly simplified. Starting from Nicholson's experiment establishing the constancy of the speed of propagation of electromagnetic disturbances, we arrive at the conclusion of the relativity of all our measure systems, and conversely, the assumption of relativity as a principle is found to involve the necessity of an electrodynamic theory of the Maxwell type. He expresses the opinion that the difficulty experienced by many physicists in adapting themselves to relativistic conceptions, while undoubtedly very largely due to the great changes rendered necessary in our ways of thinking, is aggravated by simple defects in notation, and, in a comprehensive but succinct review of classical electromagnetic theory, shows how greatly it may be simplified by the use of the tensor notation, which should smooth the way for further advance. The Cartesian components of the vector quantities are not concrete physical quantities, for they are not configurations geometrically defined independently of the system of axes. The real quantities are the vectors and the scalars, so that the direct vector analysis, in addition to the simplification resulting from the reduction of every group of three equations to one, possesses the advantage of fixing attention on the physical quantities themselves. The first and second classes of vectors, as Maxwell calls them, are adequately imaged, respectively, by an arrow and by a disc with given direction of rotation. In the enumeration of the principal formulæ of electromagnetic theory a duality occurring in certain pairs forces itself upon the attention, and has been variously interpreted as a dualism in electricity and magnetism, in the scalar and vector potentials and in the field and the induction. Relativity resolves them all in a single interpretation. In the ether itself we may assume the absence of anything in the way of either dielectric or magnetisable media, so that $D = E$ and $B = H$. And the existence of homogeneous media with constant inductance and magnetic permeability differing from unity may well be supposed to consist of free or bound electrons accessible to measurement only by a process of averaging, and Lorentz has proved that the electrodynamics of the ether, supplemented by calculation of these averages, gives an electrodynamics of continuous media which agrees with observation. G. W. DE T.

972. *An Electroculture Problem.* **C. Chree.** (Phys. Soc., Proc. 33. pp. 377–385; Disc., 386–387, Aug., 1921.)—The problem is that presented by a number of fine parallel wires at the same height above the ground—treated as a plane surface—all charged to the same potential.

The chief object is to investigate how the potential gradient at ground level depends on the height and spacing of the wires. A second object is to find how the potential gradient varies with the height above the ground. The cases of a finite and an infinite number of wires are considered. AUTHOR.

973. *Dimensions of Electrical Units.* **R. Rinkel.** (Zeits. f. Physik, 8. 2. pp. 105–109, 1921.)—The author suggests the derivation of the dimensions of electrical units from the following conception. The passage of a current along a conductor might be regarded as the setting into rotation of electrons in a plane normal to the direction of flow. Simultaneously this rotatory movement is propagated along the conductor with the velocity of light. In conductors the rotations would be continuous, in insulators the electric intensity would produce an angular twist of the electrons. On this view, *electromotive force* would be regarded as torque (ML^2T^{-2}), *current* as an angular velocity (T^{-1}), and *resistance* (ML^2T^{-1}), the torque necessary to produce unit angular velocity. *Quantity* would have no dimensions. *Capacity* ($M^{-1}L^{-2}T^2$) would be the e.m.f. necessary to produce unit electric twist. *Self-Induction* (ML^2) corresponds to moment of inertia. The whole range of electrostatic and electromagnetic phenomena may be covered in this way and the system proposed would be unique. L. L.

974. *Experimental Researches on the Origin of Frictional Electricity.* **C. Christiansen.** (K. Danske Videnskabernes Selskab, Math.-fys. Med. 11. 7. pp. 1–17, 1919.)—A posthumous paper devoted mainly to a description of the "condenser-ballometer," the apparatus with which the author carried out his investigations. It is illustrated with diagrams and is of a mathematical nature which does not allow of abstraction. E. F.

975. *The Dipole Rotation Effect in Dielectric Liquids.* **P. Lertes.** (Zeits. f. Physik, 6. 1. pp. 56–68, 1921. Phys. Zeits. 22. pp. 621–622; Disc., 622–623, Nov. 1 and 15, 1921. Paper read at the Deut. Physikertag, Jena, Sept., 1921.)—The Born theory for the mobility of electrolytic ions seeks to explain why the atomic ions of the alkali metals and halogens deviate from the otherwise valid rule that ionic mobility increases with decreasing atomic volume. This anomaly should depend on the fact that the solvents are dipole liquids (Debye), which become strongly polarised by ionic charges in the region and thereby oppose a resistance to the wandering of the ions. The existence of this resistance has been demonstrated experimentally by Born as follows:—If a dipole liquid be introduced into an electrostatic rotating field, the dipoles will tend to set themselves in the direction of the field, but in consequence of the viscosity of the liquid this will be prevented so that a turning moment will arise which sets the liquid in rotation. Similar rotation effects must be exerted by the wandering ions on the dipoles of the surrounding liquid whereby energy is given up and the ions retarded. The object of the present paper is directly to establish this rotation effect for a series of dipole liquids, and, thereby, to afford experimental support for the Born theory of ionic mobility. Born's theory states that a spherical liquid dipole in a rotatory electrostatic field must experience a turning moment $L = E^2 . \frac{4}{3}\pi R^3 . \omega\eta(M/kT)^2$, where E denotes field strength, R the sphere radius, W the frequency of the field, η the viscosity constant of the liquid, M the dipole moment, k the Boltzmann constant, and T the absolute temperature. The rotation effect only occurs with high-frequency fields, and this has superposed upon it a similar rotation effect which is due to the conductivity of the liquids and which at low frequencies is very much greater than that to be measured. This subsidiary effect has been accurately investigated in an earlier paper [Abs. 1921 (1921)], and was shown to increase linearly at first with rising frequency according to Lampa's theory, and after attaining a maximum to decrease hyperbolically. The position of the maximum and the magnitude of the effect were found to be a function of the dielectric constants and the conductivity. This conductivity effect must become smaller with increasing frequency, while the Born dipole effect, on the other hand, increases linearly. Section 2 of the paper contains an account accompanied by diagrams of the experimental arrangements employed. Sections 3 and 4 deal with the high-frequency fields and their measurement. Section 5 is devoted to a discussion of the results when petroleum, benzol, and glycerine were employed. Benzol and petroleum were deemed to have no dipoles since their dielectric constants show no appreciable temperature dependence, but glycerine which shows this dependence and is also a trihydroxy compound should possess a dipole constitution. Glycerine was also chosen on account of its very low conductivity and high viscosity, and therefore should be suitable for showing the Born effect. The great drawback is its affinity for water, so that determinations of its constants compared with those for amyl alcohol and water were made, and a table of results is given. Section 6 is devoted to a comparison between theory and experiment. Section 7 contains a discussion of the sources of error and their magnitude. The conclusion is drawn that the Born theory of electrolytic ionic mobility holds good. Corresponding to the theory, it was found that the observed rotation effect increases linearly on the one hand with rising frequency, and on the other, increases with magnitude of the dipole moment and the viscosity constant. No effect was observed for liquids which have no dipoles. Under the assumption that the molecular friction is equal to the usual viscosity constant, the dipole moments were determined from the measurements for several liquids and their order of magnitude found to be in agreement with Debye's calculations. The observed dipole moments are probably too small, since the lack of homogeneity of the field in its extreme parts has doubtless an influence on the accuracy of the measurements. H. H. Ho.

976. *Experimental Researches on the Relation between Terrestrial Electricity, the State of the Atmosphere, and Solar Activity.* **A. Nodon.** (Comptes Rendus, 173. pp. 722–724, Oct. 24, 1921.)—Simultaneous measurements have been made of earth currents and conductivity in directions N.S., E.W., and at 45° to these; of the horizontal component of the earth's magnetic force; of the variations of charge of an electrometer completely enclosed in a metal case, due to some form of penetrating radiation; and of disturbances visible on the solar disc. Periods of solar activity are found to be in a general way periods of disturbance of the other elements, all of which vary together in the opposite sense to the variation of solar activity. Atmospheric conditions are also considered, it being observed that periods of electrical activity accompany disturbed weather, while electrical conditions are quiet in fine weather.

M. A. G.

DISCHARGE AND OSCILLATIONS.

977. *Resonance Wave-Lengths of the Selective Electric Photoelectric Effect; the Lindemann Formula.* **F. Gross.** (Zeits. f. Physik, 7. 4 and 5, pp. 316–322, 1921.)—A theoretical paper dealing with a method of calculating the resonance frequencies of the photoelectric effect in metals. A simple relation is deduced which gives the wave-lengths at the resonance-maxima for a metal having several of these.

The Lindemann formula is found to agree accurately with all known resonance maxima of the metals. A. B. W.

978. *Mechanism of Photoelectric Conductivity* **B. Gudden.** and **R. Pohl.** (Zeits. f. Physik, 7. 1. pp. 65–72, 1921.)—Experiments have shown that when an insulating material is subject to illumination the photoelectric current is constituted by a migration of negative carriers. In consequence the region of illumination is the seat of a positive space-charge, as in the case of discharge tubes. If only a portion of the current path is illuminated, so that the negative carriers have to traverse unilluminated crystal, the migration takes place without losses. A. W.

979. *Selective Photoelectric Effect in Metal Layers Produced by Kathodic Sputtering.* **F. Gross.** (Zeits. f. Physik, 6. 5 and 6. pp. 376–399, 1921.)—The author has observed with mirrors of gold and copper, formed by kathodic sputtering, a selective photoelectric effect. In these cases, however, it has not been possible to make measurements in the range of the resonance-maxima, which probably occur in the region $\lambda < 250\ \mu\mu$. For Ag and Pt no definite decision has been reached. Differences are observed for Au deposited on quartz or on glass. The effects with Au and Cu are reproducible with an accuracy of 15 %. Platinum and Ag behave in a very irregular manner and the results are therefore inconclusive.

A. B. W.

980. *Impact-Rays and Ionisation by H-Canal Rays.* **K. Glimme** and **J. Koenigsberger.** (Zeits. f. Physik, 6. 4. pp. 276–297, 1921.)—Reference is made to the work of Baerwald and others [Abs. 1780 (1921)] on the ionisation produced by canal-rays. The author now describes an investigation of the part played by the impact-radiation in the production of ionisation by hydrogen canal-rays. The primary hydrogen-rays produce in the hydrogen gas an impact-radiation of lower velocity by impact with the stationary gas molecules. The relative number of collision particles and incident hydrogen-rays was determined by means of a Faraday cylinder and the energy by means of a thermo-junction. The lower the velocity of the collision particles, the greater must be the angle made by them to the axis of the primary beam. The impact-radiation lies in a cone of which the direction of the primary beam is axis. At higher gas pressures the collision particles become more numerous, their mean velocity is less and the particles are more scattered; experiment and theory are in good accord. The magnitude of the ionisation per particle of the canal-rays, including that of the secondary impact-rays, is found to be in close agreement with that obtained by other observers, notwithstanding wide differences of experimental conditions and in the velocities of the hydrogen particles. The dependence of the ionisation of the canal-rays on pressure and velocity is, however, not in exact agreement, divergences being due to the impact radiation. A. B. W.

981. *Photoelectric Conductivity of Cinnabar.* **H. Rose.** (Zeits. f. Physik, 6. 3. pp. 174–184, 1921.)—Gudden and Pohl [Abs. 502 (1921)] have shown that cinnabar exhibits a considerable photoelectric conductivity, with a maximum at about the limit of optical absorption. Research has shown that cinnabar exhibits weak pleochroism [see Abs. 833 (1922)]. Corresponding to this it has been found that in general there are two maxima of photoelectric conductivity, that corresponding to the extraordinary ray lying nearer the short-wave region than that corresponding to the ordinary ray. In the direction of the principal axis only a single maximum is found since no pleochroism can occur in this direction. The difference of absorption of the two rays causes for one and the same wave-length a difference of photoelectric conductivity in the direction of the principal axis and perpendicular thereto. With increasing temperature the conductivity maxima shift towards the longer wave-lengths, the amount of shift (about 0·27 $\mu\mu$ for 1 deg. C. rise) being the same for both the extraordinary and ordinary rays. It was also found that the photoelectric conductivity increases with temperature. A. W.

982. *Influence of Free Ions on the Canal-Ray Discharge.* **J. Koenigsberger.** (Zeits. f. Physik, 4. 2. pp. 284–287, 1921.)—In connection with the work of Rüttenauer on the canal-ray discharge [see Abs. 185 (1922)] the author calculates the effect of free ions on the relative number of charged and uncharged canal particles. A. B. W.

983. *Relative Affinity of Gas Molecules for Electrons.* **L. B. Loeb.** (Phil. Mag. 43. pp. 229–236, Jan., 1922.)—In a previous paper [Abs. 1131 (1921)] the author showed that in some gases the electron must on the average make a number *n* of impacts with the molecules of a gas before it can strike one in such a manner as to attach to it to form a negative ion. The quantity *n* was found to vary with the nature of the gas. The present paper discusses the bearing of a recent study of electronic mobilities in nitrogen on the determination of *n* [see next Abstract]. An equation is obtained which gives the values of *n*, the constant of attachment, with a greater degree of certainty than the one previously given. The equation is, however, not yet satisfactory, owing to the lack of knowledge of the electronic mobilities in the various gases. Certain experiments showed the existence of negative carriers in pure nitrogen whose mobility was five times as great as those found by earlier observers, and so determinations were made of electron mobilities in pure nitrogen and in a number of other gases. From the results obtained the values of *n* for the different gases were calculated from the equation mentioned above. The results show that in spite of the uncertainties in the determination of *n*, it varies through such a wide range of values for the different gases, that the order of magnitude of the quantity alone furnishes a characteristic quantity of the gas in question. A. W.

984. *Mobilities of Electrons.* **L. B. Loeb.** (Nat. Acad. Sci., Proc. 7. pp. 307–310, Nov., 1921. Phys. Rev. 19. pp. 24–37, Jan., 1922.)—Recent determinations of the mobilities of electrons in nitrogen and hydrogen at atmospheric pressure [see preceding paper and Abs. 1131 (1921)] gave results so much higher than the values found by earlier investigators that it was thought necessary to carry out further experiments. The method of measurement was the Rutherford alternating-current method; the electrons used were photo-electrons liberated from one of the plates by ultra-violet light, and particular care was taken to avoid the presence of any impurities in the ionisation chamber. The values found for the mobility (K) of electrons in nitrogen were extremely high. Further, the value of K was not a constant, but varied with the field strength and gas pressure. The results indicate a formula of the type $K = a/(b + V/pd)$, where a and b are constants, p is the pressure, V the voltage, and d the distance apart of the plates. A more detailed account of this work will be published later. The experiments are being extended to hydrogen, and if possible to other gases. A. W.

985. *Characteristics of the High-Frequency Arc Stream.* **G. Polvani.** (N. Cimento, 23. pp. 59–75, Jan., 1922. Paper read before the Soc. Ital. di Fisica.)—Describes stroboscopic experiments on the light emission in the arc stream with various electrodes at a frequency of 6000 complete periods per sec. and a current of about 10 amps. The apparatus used is described and illustrated in the paper. The electrodes used were (*a*) solid carbon, (*b*) cored carbons in which the core was of lampblack and potassium silicate, calcium fluoride (yellow arc), carbon and $SrCl_2$, carbon and $BaCl_2$, carbon and $Pb(NO_3)_2$. The core area was 1/22 of the total electrode area which was 95 mm.². For short arcs the variation of intensity of the different spectral lines was found to be very closely in phase with the arc current; as the arc was lengthened, however, the amplitude of the variations was found to be much reduced, the reduction being greater for the stronger lines. It was found that in a long arc if the part near the electrodes was excluded, the middle region gave a spectrum which did not suffer any variation with the current oscillations and was, in fact, as steady as a d.c. arc. On the other hand, in the regions near the electrodes the pulsations increased in amplitude as the intensity increased. Experiments were also made (*c*) with rods of Fe, Cu, or Ni as one electrode. These arcs are difficult to strike on alternating current, and a d.c. starting current was used. In these arcs the intensity in the middle of the arc does not follow the current throughout the period, but simply shows an increase when the metal is positive, in fact the arc appears to exert a valve action in favour of the passage of current from metal to carbon. For arcs (*d*) between carbon as one electrode and a carbon shell containing a core (1/5·7 total area) of one of the metals Cd, Pb, Sn, Bi, Zn, Al, or Ca, as the other, the general behaviour was as in the case of arcs of class (*b*) above, but the observations were complicated by the presence of the carbon shell. The author concludes that the high-frequency arc behaves differently from either the low-frequency a.c. arc or the spark discharge, in that it has a pseudo-stationary region at the middle part of the arc stream. J. W. T. W.

986. *Arc between Carbon and Mercury Electrodes.* **A. Sellerio.** (N. Cimento, 23. pp. 31–57, Jan., 1922.)—The arc stream between Hg (+) and C (—) in air at small currents is a tranquil jet of green vapour without surrounding flame. The paper describes experiments carried out on this arc with the object of determining the velocity of the arc stream. The jet is always normal to the crater which is a circular depression (3 to 5 mm.)

surrounded by a ring of mercury oxide. Figures are given in the paper to illustrate the growth of current and voltage to a stable condition of the arc. Measurements were made of the rate of mercury consumption in a given time, with a known current and crater diam. It was found that the ionisation coefficient (proportion of atoms leaving the electrode which take part in the transference of electricity) was of the order of 1/5 and the velocity of the stream was between 10 and 30 metres per sec. This is in agreement with similar measurements which have been made by other means. The current density is high, being of the order of 300 to 1000 amps./cm.^{2}. The crater area varies directly as the current. Curves are given to exhibit the variation of voltage with arc length at constant current. The relation is approximately linear. The cyanogen spectral lines are absent in this arc. J. W. T. W.

987. *Explosive Potential in Carbon Dioxide at High Pressures.* **C. E. Guye** and **P. Mercier.** (Arch. des. Sciences, 4. pp. 27–37, Jan.–Feb., 1922.) —The investigation of the limits within which the law of Paschen is applicable to compressed gas has already been made the subject of research [see Abs. 903 (1920) and 190 (1922)]. In the present paper the results of a series of experiments carried out in CO_2 are described. The general conclusions arrived at are as follows:—The effects obtained in CO_2 with hemispherical electrodes of 15 mm. diam. are similar to those obtained in nitrogen with the same electrodes. Observations were made with electrode distances $d = 5, 4, 3, 2, 1,$ and $0 \cdot 5$ mm. Leaving out of consideration the case for $d = 0 \cdot 5$ mm. it is found that the law of Paschen, under the form $V = f(pd)$ holds within an approximation of about 2 %, the max. pressure being 25 atmos. Making the same reservation, the law of Paschen under the form $V = f(md)$ is found to hold within an approximation of 3 %, the max. pressure being 20 atmos. There are, however, strong reasons for believing that the form $V = f(md)$ is the more exact, and that the divergence observed between the results obtained and the values which would verify Paschen's law may be due to the want of uniformity of the field when experimenting at great distances or to the unequal distribution of the ions, which appear to play an important part in the study of small explosive distances. The inconveniences which result from the alteration of the electrodes and bring about an increase in the disruptive potential are considerably lessened when use is made of an accessory source of ionisation such as X-rays, radium, or a Nernst lamp. A. E. G.

988. *Measurement of Damping of Oscillatory Circuits.* **H. Pauli.** (Zeits. f. Physik, 6. 2. pp. 118–126, 1921. From the Telegraphentechn. Reichsamt.)—This paper discusses the accurate determination of the damping of oscillatory circuits. Theory of the method is first given, and is followed by numerical data for particular cases. A. W.

989. *Theory of the Striated Discharge.* **J. J. Thomson.** (Phil. Mag. 42. pp. 981–1001, Dec., 1921.)—By making the assumption that at low pressures the negative ions are electrons, and that in consequence of their great mobility as compared with the positive ions, the current is carried by the electrons, a great simplification is made in the equations which represent the distribution of the electric force. Investigation of the energy of the electrons and the intensity of the electric force along the line of discharge in a vacuum tube then shows that when the pressure is below a certain value, depending on the nature of the gas in the tube, there will be periodic variations in the energy of the electrons and the electric force, and that these variations would produce periodic variations in the luminosity such as are observed in the striated discharge. The effect of impurities and of the diameter of the tube is also dealt with. A. W.

990. *Discharge Potential for Rapid Electric Oscillations.* **A. Leontiewa.** (Phys. Zeits. 23. pp. 33–35, Jan. 15, 1922.)—This paper gives the results of measurements of the sparking potential for different spark lengths using electric oscillations of wave-lengths from 2 mm. to 42 m. The sparks took place between spheres 5 mm. in diam. The results show that the sparking potential under the conditions employed is a linear function of the spark length. [See Abs. 983 (1918).] A. W.

991. *Production of Feebly-Damped Short Electric Waves.* **W. Arkadiev.** (Phys. Zeits. 23. pp. 35–36, Jan. 15, 1922.)—An arrangement of two Hertzian oscillators combined with a wire grating is described, by means of which electric waves of a few cm. wave-length may be obtained with small damping. The use of the grating reduces the damping to about one-quarter of that obtained without it. A. W.

992. *Short Undamped Electric Waves. Dielectric Constant of Water.* **F. Holborn.** (Zeits. f. Physik, 6. 5 and 6. pp. 328–338, 1921.)—Various arrangements are described for the production of short undamped electric waves. The first of these is similar to one described by Eccles and Jordan [Abs. 932B (1919)]. A modification of this enabled a wave-length of 3·5 m. to be obtained. Two valves (type R.S. 5 or R.S. 5 C ii, Siemens and Halske) were used. Parallel wires are joined to the anodes, a sliding bridge across these being connected to the positive terminal of the anode battery (400–500 volts). Another pair of parallel wires are joined to the grids, a sliding bridge across these being connected to the positive terminal of the grid voltage battery (18–24 volts). The negative terminal of the grid battery is joined to the lead connecting the two filaments, which are in series, and thence to the negative terminal of the anode battery. With this arrangement wave-lengths of from 8 m. to 3·5 m. can be obtained, the power taken being 1·5 to 2 watts for wave-lengths between 8 and 4·5 m. The wave-lengths were measured by means of an inductively coupled arrangement of parallel wires.

Dielectric Constant of Water.—The dielectric constant of water was determined by comparing the measurements of the half-wavelength along the coupled parallel wires in air and in water. The square of the ratio, providing the water conducts only feebly, gives the dielectric constant. The mean value thus obtained was 81·5 (1) ± 0·2 (7). A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

993. *Absolute Value of the Ohm.* **E. Grüneisen** and **E. Giebe.** (Physikal.-Techn. Reichsanstalt, Wiss. Abhandl. 5. p. 1, 1921. Zeits. Instrumentenk. 42. pp. 59–60, Feb., 1922.—Abstract.)—Describes the results of a new determination of the absolute ohm in terms of the int. ohm, by means of a self-inductor, the product of induction and frequency being of the same dimensions as resistance. The 13 inductors employed are fully described in the paper, and their calculated self-induction is assumed to have an accuracy of about 1 in a million. The frequencies used were 332, 500, and 720. The results of all the measurements agreed within one part in a hundred thousand, and the final result is found to be 1 int. ohm = 1·00051 ± 0·00003 abs. ohm. Hence the length of the standard Hg column at 0° C. to give 1 abs. ohm is 106·246 cm. The above determination agrees well with the value of the ohm found by F. E. Smith at the National Physical Laboratory, viz. 1 int. ohm = 1·00052 abs. ohm. The standards at the two laboratories are, however, connected by the relation: 1 int. ohm (P.T.R.) = 1·00003 int. ohm (N.P.L.). Thus the absolute ohm can now be reproduced with the same accuracy as the international ohm. J. W. T. W.

994. *Temperature Coefficient of Electrical Resistance of Pure Metals.* II. **L. Holborn.** (Zeits. f. Physik, 8. 1. pp. 58–62, 1921. From the Physikal. Techn. Reichsanstalt.)—In a previous communication [Abs. 1327 (1919)] the author has given the results of an investigation of the temperature coefficient of electrical resistance of pure metals showing that the higher the degree of purity the greater the value of this coefficient. The Ni used was commercial and further measurements have now been made on some test pieces prepared from purer samples of Ni powder. The powder was melted in a silica tube, *in vacuo*, and a test piece cut from the casting. Ni wire was also made, using the method adopted in the preparation of the tantalum lamp filaments. These latter specimens usually contained Si and gave a much lower value for the temperature coefficient than those from the cast. Measurements are also recorded on Co and Al. Contrary to experience with other metals, Al showed no greater increase in the temperature coefficient as the degree of purity was raised. The table below gives the values of the mean temperature coefficient between 0° and 100° C. for annealed specimens of the highest degree of purity.

Ni	675×10^{-5}	Rh	443×10^{-5}	Iv........	411×10^{-5}
Co	658	Mo	435	Ag	410
Fe	657	Cu	433	Au	400
W	465	Cd	424	Pt	392
Bi	446	Pb	422	Pd	377
Al	445	Zn	415	Ta	347

L. L.

995. *Electric Conductivity of Mixtures of Mercury Isotopes.* **W. Jaeger** and **H. v. Steinwehr.** (Zeits. f. Physik, 7. 2. pp. 111–115, 1921. From the Physikal.-Techn. Reichsanstalt.)—The authors obtained two mixtures of mercury isotopes, differing by 0·31 per mille in density, from G. v. Hevesy, whose direct determination they confirm. Either of the two mixtures or ordinary mercury was charged into a U-capillary immersed in petroleum within a Dewar vessel and the resistance determined by means of Kohlrausch's galvanometer arrangement with overlapping shunt. The temperature varied very little, from 16 to 18° C. Reduced to 17° C., the resistances found in 27 observations were 0·4755975, — 5987, — 6006 for the light, normal, and heavy mercury, showing deviations of $\mp 3 \times 10^{-6}$, which would fall within the limits of the errors of observation. The capillary having a diameter of 0·5 mm. the mercury should touch the glass wall uniformly within ¼ $\mu\mu$ to keep the resistance change within 1×10^{-6} of its value. The accord realised is hence remarkable. H. B.

996. *Measurements of the Deviations from Ohm's Law in Metals at High Current-Densities.* **P. W. Bridgman.** (Nat. Acad. Sci., Proc. 7. pp. 299–303, Oct., 1921.)—The application of the electronic theory to electric conduction in metals leads to the conclusion that at high current, densities Ohm's law will not hold. Experiments to detect such deviations have hitherto been unsatisfactory owing to change of resistance of the metal due to the large rise of temperature. The author eliminates this temperature effect, the specimen being traversed simultaneously with a large direct current and a small superposed alternating current. Resistance to direct current is measured with bridge and galvanometer, and, at the same time, resistance to alternating current with a telephone. From the difference of the two resistances the deviation from Ohm's law may be deduced. A " microphone " effect due to alternating heat supply is eliminated by making determinations at a number of frequencies (320–3750 per sec.) and extrapolating for infinite frequency. Measurements were made on Au and Ag in the form of thin leaf cemented to glass strips. Two thicknesses of Au were used (8×10^{-6} cm. and $1{\cdot}67 \times 10^{-5}$ cm.) and one of Ag (2×10^{-5} cm.). Current densities up to 5×10^6 amps./cm.^{2} were employed. The resistance is greater at the higher current density. The deviation from Ohm's law is of the order 1 % for 5×10^6 amps./cm.^{2}. It increases more rapidly than the square of the current and is greater with the thicker gold film. The existence of the effect for currents of the order 10^6 amps./cm.^{2} means that the free path must be much larger than supposed on the classical electron theory, and accordingly the number of free electrons much less. L. L.

997. *Constitution of Selenium.* **H. Pélabon.** (Comptes Rendus, 173. pp. 1466–1468, Dec. 27, 1921.)—The author has shown [see Abs. 1818 (1921)] that it is possible to prepare samples of grey selenium, the specific resistance of which, measured at ordinary temperature may vary within very large limits (from some ohms up to several millions of ohms). It now appears that these various specimens of grey Se are formed of mixtures in varying proportions of two modifications, α and β. The modification α has a very high resistivity; the modification β, on the contrary, is a good conductor. Methods of preparing specimens of Se containing selenium α in one case and mainly selenium β in the other are described. In the case of α it is found that the resistivity is several million ohms at ordinary temperature. When the temperature is raised the resistivity diminishes very rapidly at first, then more slowly. Towards 200° the resistivity is about 70,000 ohms, and, if the heating is continued to 218°, the substance melts. The fusion is accompanied by a very sharp increase of resistivity, which reaches very nearly the same value as at 15°. If the temperature is increased regularly until the liquid boils, it is found that the resistivity ρ satisfies the equation already given, $\log \rho = 8{\cdot}506 - 0{\cdot}0095t$. The rapid variation of ρ under these conditions must be due to the gradual change with the absorption of heat, of the modification α into the modification β. At high temperatures the two forms are in equilibrium, and this equilibrium is displaced in the sense $\alpha \longrightarrow \beta$ by elevation of temperature. At low temperatures the selenium β is not stable; it is easily changed into the α variety by oscillations of the temperature, between 15° and 200° for

example. The resistivity of the substance at 15° increases very slowly at first with each temperature oscillation, then more and more rapidly, so that it is possible to obtain grey selenium of such resistivity as may be wanted. After a large number of oscillations it becomes finally changed into the α variety which is characterised by its very high resistivity.
A. E. G.

998. *Calculation of the Mutual Induction of Coaxial Circles.* **L. V. King.** (Roy. Soc., Proc. 100. pp. 60–66, Oct. 4, 1921. Phys. Rev. 18. pp. 139–141, Aug., 1921.)—The use of the modern calculating machine for the extraction of square roots makes the *scales of arithmetico-geometrical means* extremely convenient for the direct and rapid computation of the complete elliptic integrals. This procedure is applied to Maxwell's formulæ for the coefficient of mutual induction of coaxial circles, with the result that two new and elegant formulæ are obtained for numerical computation. Numerical examples, taken from the well-known collection of formulæ and tables for the calculation of self and mutual induction, issued by the Bureau of Standards, illustrate the advantage of the new formulæ in economy of labour.
AUTHOR.

999. *Electric Moments of the CO and CO_2 Molecules.* **H. Weigt.** (Phys. Zeits. 22. p. 643, Dec. 1, 1921. Extract of Dissertation, Göttingen.)—In order to test Debye's dipole hypothesis of the dependence of the dielectric constant upon temperature, the author determined the capacity of a condenser, heated to various temperatures, in atmospheres first of air, and then of CO and CO_2, by means of electric oscillations. The valve arrangement of Preuner and Pungs [Abs. 618 (1920)] was used and found preferable to the method of Jona [Abs. 625 (1919)]. The moments found are:

$$\mu_{CO_2}=(0\cdot1420\pm0\cdot0017)\times10^{-18} \quad \text{and} \quad \mu_{CO}=(0\cdot1180\pm0\cdot0016)\times10^{-18}.$$

These values agree with the index of refraction after Lorentz-Lorenz, although extrapolation from the ultra-red had to be resorted to, which is anomalous for dipole-gases.
H. B.

1000. *Temperature and Pressure Dependence of the Dielectric Constant and Refractive Index.* **R. Lundblad.** (Zeits. f. Physik, 5. 5 and 6, pp. 349–362, 1921.)—According to the classical theory of dielectrics, the dielectric constant ϵ should obey the Clausius-Mossotti law as a function of the molecular number N per cm.^{3}, namely: $[(\epsilon-1)/(\epsilon+2)]1/N=$ const., and the refractive index n be in accordance with the Lorentz-Lorenz law: $[(n^2-1)/(n^2+2)]1/N=$ const. Under the assumption of spherical molecules, these laws are valid within a wide range. Recently Faxen [Abs. 696 (1921)] has shown that every direction of the molecule is equally probable, and that the molecule possesses only a single isotropic resonator. The first assumption, which is retained in the present investigation, confines the theory to isotropic liquids and gases. The second assumption is now examined, as its author asserts this generalisation to be sufficient for the qualitative explanation at least, of deviations from the above laws. Section 2 deals with experimental results and the previous theories of Debye (rigid dipoles), Jona (association), and finally Boguslawski and Czakor, who assume that the displaced electrons take part in thermal movement and that the mode of union is not purely quasi-elastic, whereby positive as well as negative effects of temperature changes become comprehensible. Section 3 examines the bases of the previous theories, and Section 4 is devoted to calculations. Section 5 considers the dispersion of light in gases, and Section 6 the dependence of temperature and pressure. Section 7 discusses the formulæ of Wiener and Klein. The dielectric constant and refractive index of a liquid mixture are evaluated in Section 8, while Section 9 discusses the range of validity and possibility of extension of the theory. The treatment adopted for ascertaining the behaviour of isotropic liquids and gases in electrostatic and optical fields is based on the exchange effect of electrons in the same molecule and the action between these electrons and those of surrounding molecules. It was found that the shape of the effective molecular surface was of profound importance. Calculation leads to a formula which the temperature and pressure dependence of the dielectric constant and refractive index support. This formula permits, in special cases, the evaluation of the inner molecular distances from dispersion measurements. Applied to hydrogen, the value $r = 1{\cdot}021 \times 10^{-8}$ was given for the distance between the dispersion electrons, which is in good agreement with theoretical gas results. H. H. Ho.

1001. *An Ohm-meter having Fluxmeter Characteristics.* **P. E. Klopsteg.** (Phys. Rev. 19. pp. 61–63, Jan., 1922.)—*The deflection of an ideal fluxmeter* in which the coil has great damping control but no torsional control, and has negligible inductance compared with its resistance, is shown to be directly proportional to the current and to the time during which it flows, for the range through which the magnetic torque is proportional to the current.

Measurement of Time Intervals with such a Fluxmeter.—In practice it would be necessary to calibrate the instrument, but the relation between deflection and time, for a constant current, should be approximately linear. A great advantage is that the range may be varied at will by proper control of the current. AUTHOR.

1002. *Polar Representation of Alternating-Current Curves.* **W. Geyger.** (Phys. Zeits. 23. pp. 102–104, Feb. 15, 1922.)—The arrangement described consists of an oscillograph element which is used to send a pencil of light through a slot in a rotating disc driven by a synchronous motor. After passing through the disc the light falls on a scale, and a series of readings are obtained corresponding to different time-intervals during a single period. These values are then plotted to give either the polar wave-curve or the Cartesian curve. [See Abs. 204 (1922).] A. W.

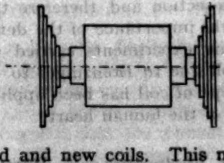
1003. *New Methods for Maintaining Constant Frequency in High-Frequency Circuits.* **W. G. Cady.** (Phys. Rev. 18. pp. 142–143, Aug., 1921.)—In a former communication the author showed that a plate properly cut from a piezoelectric crystal and provided with metallic coatings vibrates mechanically when the coatings are connected to a source of e.m.f. of high frequency, provided that the electrical frequency is sufficiently near the natural frequency of mechanical vibration. The absorption of energy gives the plate an effective series resistance which is a maximum at a frequency slightly below resonance and a minimum at a frequency slightly above resonance, passing through the normal value at resonance. The total range of capacity is the greater the less the vibrations are damped, and in the case of quartz it may be more than 20 times as great as the normal capacity of the plate. The accompanying change in frequency may be a very small fraction of 1 %.

This dependence of capacity upon frequency may be utilised as a frequency stabiliser by simply connecting the piezoelectric crystal in parallel to the tuning condenser of an ordinary valve oscillatory circuit. When the frequency is slightly above that at which the plate is in mechanical resonance, an increase of the tuning condenser is accompanied by a nearly equal decrease in the effective capacity of the plate, and a certain increase in tuning capacity abruptly stops the plate vibrating, when the frequency abruptly decreases. A similar effect occurs when the variable condenser is reduced.

A specific example of the use of such a crystal is given, and it is shown that the effect can be obtained for any frequency by the use of a plate of appropriate length. Two further methods of connecting the crystal in the valve circuits are described. B. J. L.

1004. *Determination of Small Radiation or Electric Current Variations by means of Capacity Measurements.* **F. Kock** and **G. Schwelkert.** (Phys. Zeits. 23. pp. 123–125, March 1, 1922.)—Methods of measuring small capacities and capacity variations by means of coupled oscillatory valve circuits have been given in various papers [Abs. 746 (1920)]. The present paper shows how these methods may be employed for estimating small variations of radiation or of electric current. In the first arrangement described one end of one of the plates of a small condenser is connected to the end of a bolometer strip which is kept taut by a spring; the other end of the plate (which is at right angles to the bolometer strip) is hinged. Thus any variation of the length of the bolometer strip causes a variation in the distance apart of the condenser plates, and this can be measured by the variation of the heterodyne note due to the coupled circuits used. In a second arrangement the bolometer strip is arranged as in a hot-wire ammeter, and the sag is utilised to cause variations in the capacity of a small condenser. Similar arrangements are described for use with electric currents. Using a hot-wire type of instrument, the " hot-wire " consisting of a bronze strip 7·5 cm. long, 0·01 mm. thick, and 0·25 mm. wide, connected to a condenser, with plates 3 × 3 cm. and 0·2 mm. apart, the sensitiveness was 3 milliamps. With a heating current of 10 milliamps the sensitiveness was increased to 5×10^{-5} amp., and with improvements in the apparatus this sensitiveness may be appreciably increased. A. W.

1005. *Construction for Increasing the Secondary Energy of Induction Coils.* **F. Dessauer.** (Phys. Zeits. 22. pp. 425–429, Aug. 1, 1921.)—Describes a method of increasing the output of induction coils which is applicable both to old and new coils. This method consists in making the ends of the iron core in the form shown in the Fig., the actual end-pieces being built up of laminations. To illustrate the usefulness of this



method, the author gives the following table of the secondary currents obtained for various primary voltages and currents, with and without end-pieces :—

INDUCTION COIL WITH GAS INTERRUPTOR, WITH REGULATING RESISTANCE IN THE D.C. CIRCUIT.

Rate of interruption constant, time of contact always the same.

Two movable discs consisting of 5 *sheets* 0·5 *mm. thick and* 400 *mm. in diameter.*

Voltage of Mains.	Primary Current (amps.).	Primary Voltage behind Regulating Resistance.		Length of Spark Gap (mm.).	Secondary Current.		Percentage Generated.
		Without End-Pieces.	With End-Pieces.		Without End-Pieces (milliamps.).	With End-Pieces (milliamps.).	
110	2·65	48	55	100	0·45	1	122
110	3	52	60	100	1	2·3	130
110	3·8	56	65	100	2	4·5	125
110	4·3	58	66	100	3	5	66
110	5·5	64	67	100	5	8	60
110	3·2	52	62	150	0·5	1·5	200
110	3·6	54	64	150	1	2·0	100
110	4·5	61	71	150	2	3·8	90
110	5·3	64	78	150	3	5·7	90
110	6·8	73	80	150	5	8·5	70
220	3·2	81	91	100	0·4	1·8	350
220	5·5	92	98	100	3·2	4·5	41
220	3·2	82	90	150	0·4	1	150
220	5·3	93	102	150	2·5	3·3	33

The author considers the theory of the method, and, in particular the transfer of energy from primary to secondary, which transfer depends upon the interruption and upon the retro-action of the secondary upon the primary circuit. For this theory the original paper must be consulted. It results, however, that for the magnetic conductance of the circuit, and therefore for the inductance and transferred energy, the relation of the cross-section to the length of the air-path plays an important part, and the action of the end-pieces is such that these greatly increase the cross-section and therefore the conductance. The author further goes into the importance of the demagnetising factor and describes, with illustrations, experiments carried out with a new type of kathode-ray oscillograph due to Brenzinger to test the efficiency of these end-pieces. This type of coil has been applied to take rapid kinematographic X-ray plates of the human heart. B. J. L.

1006. U-*Tube Absolute Electrometer.* **C. Barus.** (Nat. Acad. Sci., Proc. 7. pp. **242–244**, Aug., **1921**.)—The author indicates how a modification of his electrical condenser (*ibid.*, p. 71, **1921**) can be employed as an absolute electrometer. The results obtained with this electrometer are compared with three different Elster and Geitel electroscopes. A. B. W.

1007. *Electrical Phenomena in Ore Deposits.* **C.** and **M. Schlumberger.** (Comptes Rendus, 174. pp. 477–480, Feb. 13, 1922.)—Deposits of minerals that possess metallic conductivity (i.e., the sulphides (except blende), the arseno- and antimonio- sulphides, oxides of manganese, and certain anthracites; but not carbonates, silicates, hæmatite, etc., which are non-conductors) show a difference of potential if they are so situated that a part of the deposit lies above water-level and a part below. Generally the difference does not amount to more than a few hundredths of a volt, but may reach 1 volt in the case of certain anthracitic schists. The metallic constituents must of course be continuous or connected by metallic threads. The moisture in the surrounding rocks constitutes an electrolyte. Above the water-level this moisture is rich in dissolved oxygen, but below it is somewhat impoverished in this gas. This asymmetry in the system induces a current, which produces oxygen below and hydrogen near the surface. The latter unites with atmospheric oxygen to form water, and the net result is a sort of circuit in which oxygen is transferred from the atmosphere to the water table. The current is of the order of one-tenth ampere, and in 24 hours transfers 1 gm. of oxygen from the surface to the depth. Polarisation of the circuit is prevented because the oxygen produced is used up in oxidising the minerals. The downward increase of temperature is important because it aids the dissociation and the recombination of the oxygen. W. A. R.

1008. *Mechanical Models of Chains of Electric Circuits.* **H. Wigge.** (Phys. Zeits. 22. pp. 653–657, Dec. 1, 1921.)— The paper gives the mathematical theory of a number of cases of electric circuits connected together in the form of a continuous chain. This chain may be inductance elements, condensers being in side branches; or of condenser elements, inductances being in side branches. Again the main chain may have both inductances and condensers, the latter being repeated in the branches; and more complicated combinations follow. The electrical arrangement is in each case imitated by a mechanical model. A whole quarto page is occupied by an elaborate diagram of the five electrical arrangements in one column, each accompanied by its appropriate mechanical model in a second column. The mechanical models consist of pendulums and springs. On the diagrammatic scheme, the transparent regions are indicated on some of the arrangements, the last of all having the limits of absorption shown. [See Abs. 1754 (1915).] E. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

1009. *Experiment to Test the Applicability of the Quantum Theory to the Magnetic Field.* **O. Stern.** (Zeits. f. Physik, 7. 4 and 5. pp. 249–253, 1921.)—The author gives the theory of a crucial experiment, involving the determination of the nature of the deviation impressed upon a beam of atoms projected in a magnetic field the intensity of which increases in the direction of the field. He suggests that this experiment would decide the question of the applicability or otherwise of the classical or quantum theories respectively to the magnetic field. J. S. G. T.

1010. *Experimental Determination of the Magnetic Moment of the Silver Atom.* **W. Gerlach** and **O. Stern.** (Zeits. f. Physik, 8. 2. pp. 110–111, 1921.)—From the results of nine experiments made to determine the deflection produced in a stream of silver atoms by a magnetic field, it is concluded that the magnetic moment of the silver atom is from 1 to 2 magnetons (Bohr). J. S. G. T.

1011. *The High-Frequency Reversible Magnetic Permeability of Iron.* **R. Urbschat.** (Zeits. f. Physik, 7. 4 and 5. pp. 260–267, 1921. Extract of Dissertation, Königsberg.)—In continuation of previous work [see Abs. 706 (1918)], the author finds that there is no appreciable decrease in the reversible magnetic permeability of iron for oscillations of frequencies up to 6 × 10^7 periods per sec. Moreover, no appreciable lag was found between the magnetising force and the magnetisation, a result in agreement with the recent work of Gans and Loyarte, who find that such lag only appears at much higher frequencies than those employed in the present work. Erhardt's conclusion that the damping of the oscillations is attributable to such a lag is incorrect, owing to the fact that he under-estimated the effect of vortex currents, the theory of which is developed in the present paper. J. S. G. T.

1012. *Decay of Magnetic Brake-Action on Cobalt.* **E. Drago.** (N. Cimento, 23. pp. 97–104, Jan., 1922.)—Describes experiments in which a cobalt wire was exposed for a long period (585 days) to a magnetic field. It was found that the difference, δ, between the number of oscillations executed in a given time (*a*) under the constant field of about 110 gauss, and (*b*) under an alternating field, gradually falls with lapse of time as the wire is continually exposed to the constant field. The empirical relation between δ and t (in days) is $\delta = a - b \log t - k/t$, where a, b, and k are constants. The value of δ finally falls to zero, and the wire then behaves as if made of non-magnetic material. J. W. T. W.

1013. *Problems of the Electronic Theory of Magnetism.* **[Mlle.] H. J. van Leeuwen.** (J. de Physique et le Radium, 2. pp. 361–377, Dec., 1921.)—In this paper a theory of magnetism is developed in which molecules of three defined types move according to the assumptions of the classical kinetic theory of gases. The results obtained are then compared with the parallel cases as treated by Langevin, Kroo, Lorentz, Gans, and others. L. L.

1014. *Application of the Theory of Integral Equations to a Problem of Induced Magnetisation.* **A. Anzelius.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 15. [No. 23. pp. 1–19] 1921.)—The paper consists of a mathematical study of the field about an electromagnet in an arbitrary field. A. B. C. L.

1015. *Effect of Field Direction on Magneto-Resistance.* **C. W. Heaps.** (Phys. Rev. 19. pp. 7–19, Jan., 1922.)—(1) *Theoretical Discussion.*—The fact that in general the resistance of a conductor differs slightly according to whether the magnetic field is transverse or longitudinal, may be due to two factors. First, there may be a direct effect of the field on the motion of the electrons, as predicted by the electron theories of J. J. Thomson and others. But the author shows that if Townsend's method of developing the electron theory of conduction is adopted, the variation of resistance comes out zero. Second, the effect of the magnetic field may vary with the arrangement of crystals in the conductor, and therefore with the position of the conductor if the crystal structure is anisotropic. (2) *Experiments with cast bismuth, pressed graphite, and rolled cadmium* are described in which a small bar or sheet of the material was placed in each of three mutually perpendicular positions in a field of 7000 or 8000 gauss, and resistance measurements were made for various positions of the rotatable Weiss magnet. For Bi and Cd the variations found are not symmetrical around the current direction and are evidently due chiefly to the crystal structure. For graphite the variations when the field was rotated in the plane of the sheet were within the experimental error, therefore both factors were inappreciable. These results are not conclusive, but they suggest that the Townsend theory is correct. If so, this magneto-resistance effect may be completely explained by assuming a change in the number and mean free period of the conducting electrons which depends not only on the magnetic field but on its direction with reference to the crystal axes. AUTHOR.

1016. *The Corbino-Effect in Iron.* **E. P. Adams.** (Phil. Mag. 42. pp. 677–679, Nov., 1921.)—The apparent reversal in sign of the Corbino-effect at a field of about 260 e.m. units found by Chapman [Abs. 1290 (1916)] is discussed and further experiments are carried out using discs of both electrolytic iron and Norway iron. The method of experiment is the same as that employed in previous work, with the employment of an improved design of double commutator. The results show that in neither kind of iron is there any reversal in sign of the Corbino-effect. In the lowest fields used the true Corbino-effect is so small that it can just be detected. The approximate value of the Corbino constant c, related to the Hall coefficient R, by $c = k\text{R}$, where k is the specific conductivity, is found to be $6{\cdot}5 \times 10^{-7}$ for magnetic fields between 50 and 1000 e.m. units. A tentative explanation of the apparent reversal in sign above referred to is given. A. B. C. L.

1017. *Parallel Disturbances of the Earth's Magnetic and Electric Fields.* **S. Ray.** (Zeits. f. Physik, 7. 3. pp. 201–205, 1921.)—Assuming the earth to consist of negative electric charges and positive magnetic charges, the orbital motion of the earth produces an alteration of the earth's magnetic field. The durinal variation of this field arises partly from the rotation of the earth. The author seeks to attribute the variation, at least in part, to a variation of the light-intensity of the sun. In support of his contention, he directs attention to the correlation of earth currents and magnetic variations as shown by curves given by Birkeland in connection with his theory of magnetic storms. J. S. G. T.

1018. *Measures of the Electric and Magnetic Activity of the Sun and the Earth and Interrelations.* **L. A. Bauer.** (Terrest. Magn. 26. pp. 33–68, March–June, 1921.) *Note regarding the "Earth Effect" on Solar Activity and Relation with Terrestrial Magnetism.* **L. A. Bauer.** (Terrest. Magn. 26. pp. 113–115, Sept., 1921. Paper read before the Am. Astron. Soc., Aug., 1921.)—The first paper is a summary of a number of recent papers by the author and is divided into four sections, of which the first gives a general indication of the character of some of the problems which are being investigated by the Department of Terrestrial Magnetism. The second section is devoted to a discussion of a measure of solar activity suitable for use in seeking relations with terrestrial magnetic and electrical activity. It is found better, for this purpose, to use some measure of the variability of sun-spottedness during a solar rotation than to employ the sun-spot numbers themselves. A satisfactory measure for most purposes is provided by taking the average departure, irrespective of sign, of the daily sun-spot numbers from their monthly mean. The advantage of such "solar-energy numbers" over the sun-spot numbers alone is particularly evident when comparisons of solar and terrestrial phenomena are made over short periods, comparable, for example, with a solar rotation. Even closer relationships are anticipated when account is also taken of certain solar prominence data.

A discussion of a measure of terrestrial magnetic activity occupies the third section, a quantity $\epsilon H\delta H$ being arrived at as satisfactory for comparison with solar changes. Here H is the horizontal intensity, δH the variation or range of variation of H during the interval considered, and ϵ a numerical constant. The value derived from a single station in middle latitudes is sufficient, since stations widely distributed over the world give values in close agreement. The last section, together with the second paper, gives an abstract of results, to date, of inquiries by the Department into relationships between solar activity, terrestrial magnetic phenomena, and terrestrial electrical phenomena. Amongst other results support is found for the possibility of an "earth-effect" on solar activity (indeed of planetary influence in general), manifested by an annual periodicity of sun-spot activity, probably connected in some way with the return into space of a portion of the electrified particles received from the sun. The heliographic distribution of prominences leads to a suggestion that they form, with sun-spots, the result of a system of electric currents in the sun, similar to that indicated for the earth by the line integrals of magnetic force [see Abs. 698 (1921)]. The results show, too, that atmospheric electricity, like terrestrial magnetism, is probably controlled by cosmic factors, relationships having been demonstrated between solar activity, on the one hand, and potential gradient and vertical conduction-current on the other. For other results reference must be made to the papers.

M. A. G.

1019. *Magneto-Chemical Examination of Constitutions in Mineral Chemistry.* I. *Sulphur Acids.* **P. Pascal.** (Comptes Rendus, 173. pp. 712–714, Oct. 24, 1921.)—Magnetic molecular susceptibilities have been determined for inorganic oxy-sulphur compounds, hydroxylaminesulphonates, aminosulphonates, sulphinic and sulphonic acids, sulphoxides, and sulphones. The magnetic susceptibilities for the groups SO_2, SO_3, and SO_4 form an arithmetic progression, the common difference, 46×10^{-7}, being the atomic susceptibility of ethereal or alcoholic oxygen. Consequently the presence of the SO_2 group of the sulphones must be assumed in sulphuric acid, $SO_2(OH)_2$, and in sulphonic acids, $R{\cdot}SO_2{\cdot}OH$. Similarly, the results obtained indicate the formula $OH{\cdot}SO_2{\cdot}SH$ for thiosulphuric acid, $OH{\cdot}SO_2{\cdot}SO_2{\cdot}OH$ for dithionic acid, and $OH{\cdot}SO_2{\cdot}S_n{\cdot}SO_2{\cdot}OH$ for the higher thionic acids. The sulphites, sulphinates, and sulphoxydes have constitutions different from the preceding, the values obtained indicating non-saturation of the molecule. Thus sulphurous and sulphinic acids seem to contain the group SO of the sulphoxydes and to be represented by the respective formulæ $OH{\cdot}SO{\cdot}OH$ and $R{\cdot}SO{\cdot}OH$ T. H. P.

1020. *Paramagnetism of Solutions.* **G. Foex.** (Ann. de Physique, 16. pp. 174–305, Nov.–Dec., 1921.)—A study of the thermometric variations of the susceptibility of paramagnetic solutions. It comprises measurement of the absolute intensity of a magnetic field and of the susceptibility (χ) of a substance chosen as standard; an experimental study of concentrated solutions to determine the molecular fields at different concentrations; a collection of measurements of the temperature variation of the susceptibilities of crystals for different orientations with regard to the field; analogous measurements for isotropic bodies, metals, or pulverised crystals; a theoretical study of the paramagnetism of crystals and a systematic comparison of theory with experiment; and a discussion of the known facts with regard to the bend in the line which represents $1/\chi$ as a function of the absolute temperature T, for ferromagnetics at temperatures above the critical temperature θ. The summing up contains the following: (1) Very concentrated solutions may deviate from Curie's law; for such solutions, the coefficient χ follows Weiss's law, viz., $\chi(T - \theta) =$ constant; otherwise expressed, molecular fields exist in concentrated solutions. Ferrous ammonium sulphate may exist in several distinct magnetic states in a solution, each state possessing its atomic moment and molecular field. (2) Platinum and palladium possess, besides a diamagnetism independent of temperature, a paramagnetism which follows Weiss's law. At ordinary temperatures these metals have an atomic moment equal to 8 magnetons. (3) The bend in the $1/\chi$, T graph appears to be of frequent occurrence, and its importance is undeniable. (4) Siderose, dioptase, and ferrous ammonium sulphate deviate from Weiss's law at low temperatures, these deviations having been noted down to the temperature of liquid air. Siderose forms the first noted case of variations with temperature of all the principal coefficients of magnetisation of a crystal. Weiss's law is the limiting law at high temperatures. (5) By introducing anisotropic molecular fields and vectorial potential energies into the kinetic theory of paramagnetism, curves of variation of the coefficient of magnetisation of crystals with temperature have been obtained for the different cases which are known to occur. From this it follows that quanta do not appear to play any part in magnetic phenomena. G. E. A.

1021. *Electrical Resistance of the Human Body.* **F. Wenner, J. S. Martin, N. Forman.** (Phys. Rev. 18. pp. 141–142, Aug., 1921.)—The authors point out that values for this resistance by various observers differ greatly. Gildemeister [Abs. 448 (1920)], for the same part of the body obtained values ranging from 148,000 to 68 ohms depending on current, voltage, and frequency. Increase of frequency by a factor of 430 caused a decrease of resistance by a factor of 15, and he concludes that when the skin is burnt the resistance falls to a very low value. Dowse and Iredell with more consistent data, found a frequency change by a factor of 1000 gave a change of impedance by a factor of less than 2, and they conclude the resistance variation is less than the impedance variation.

The values depend on the electrode areas, condition of skin, etc., and the present authors devised a method in which such factors could have no effect upon the values obtained. In this method four connections are used, two being for the test current, while two apply the potential difference. An alternating test current was used, since this necessitates the passage of little or no current through the potential terminals, and the detector responds to a.c. only. Measurements were made within a frequency range of from 25 to 100 cycles, and no change of resistance was found by variation of either frequency or voltage. With a steady frequency of 60 cycles the resistance of the trunk was found to vary with the position of the individual and to be greater when the muscles were tense. Measurements at different times on the same individual gave slightly different values for trunk resistance, which for most individuals lies between 25 and 30 ohms. B. J. L.

1022. *X-Ray and Radium Accidents—Radio- and Radium-Pathology.* **Foveau.** (Arch. d'Él. Médicale, 29. pp. 289–298, Oct., 1921.)—Reference is made to the deaths of early X-ray workers and to the recent discussion in the general French Press regarding dangers at a distance from X-ray installations. Letulle and Tuffier have denounced the application of radium to the non-carcinomatous uterus, this resulting in mucous lesions. It is considered that in the interests of scientific progress all cases of accidents of treatment should be published. Experiment shows a photographic action up to distances of 80–100 metres from an X-ray tube and, according to blood counts on living rats, living tissue is even more sensitive.

Pathogenic conditions of the blood and heart due to X-rays have been known since 1897, and in 1914 E. Tiraboshi died, and a post mortem revealed atrophic changes of the reproductive glands and blood. The specific case of an X-ray worker, who eventually died, is given in chronological detail. The chief blood changes may be summarised as follows :—

Date.	Red Corpuscles.	White Corpuscles.	Hæmoglobin.	Lymphocytes.	Polymorphs.	Eosinophiles.	Hyalines.
			%	%	%	%	%
Oct. 1920	4,200,000	7200	85	38	60	17	—
Jan. 1921	2,700,000	1600	54	76	20	3	—
Feb. 21, 1921	2,850,000	—	45	—	—	—	—
Mar. 6, 1921	1,350,000	1030	26	Large 70 Small 65	20	5	1
Mar. 19, 1921	1,005,000	840	18	Large 54 Small 40	41	0	1

Details of blood-pressure changes are given ; the outset of anæmia coincided with the change from soft to hard tubes, the previous protection being apparently insufficient. Transfusion of blood, which was tried in this case, was without benefit.

As regards the more distant action of X-rays, this is apparently negative if we consider the freedom from burns and anæmia of patients in hospital near the X-ray installation room. War conditions, necessitating screen examinations with insufficient protection, are the cause of the high mortality of radiographers during the war.

The question of accidents due to radium when used for inoperable carcinomata, nœvi, adenomata, fibromata, etc., is discussed ; there is a distinct professional danger to radium workers.

Regaud has indicated the precautions desirable for radium workers. The accidental inhalation of radium emanation is not dangerous, but radiations are dangerous, and precautions should be taken by profiting by the law of distances, the employment of special methods of manipulation, and the use of opaque screens; the accidents observed with radium mostly resulting from ignorance of danger and absence of precautions.

The periodical examination of the blood should be an excellent means of indicating the risk incurred by a radium worker continuing such work.

B. J. L.

1023. *The Potter-Bucky Diaphragm.* **C. H. Holbeach.** (Röntgen Soc., J. 17. pp. 179–181, Oct., 1921.)—The main object of the Potter-Bucky diaphragm is to aid in obtaining radiographs of greater diagnostic value when dealing with the heavier parts of the body, such as the spine, kidney, and pelvis region, more particularly in cases where the patient exceeds the average weight. The Bucky principle depends on the selective action of a number of lead strips set radially to the source of X-rays and forming what is known as a "grid." The grid was in the first instance stationary, and, although it served its purpose in cutting out the secondary and scattered radiation, its image was recorded on the emulsion and disfigured the radiograph. The main improvement on the Bucky grid is due to Potter, who devised a means of eliminating grid shadows by applying to the latter a constant and uniform motion. The present Potter-Bucky grid consists of alternate strips of lead 1/50 in. thick, set parallel with carefully selected wooden slips ⅛ in. thick. The whole is clamped in a rigid cradle, which is set radially to the focal spot of the X-ray tube, in such a manner as to allow the radiation to pass between the lead strips without impinging on their sides. The cradle is mounted on ball-bearing rollers, which are caused to run on a curved track of 25 in. radius. The movement of the diaphragm is actuated by a spring, and its speed and constancy are controlled by means of an oil damper or dashpot, and the time of travel is operated by a needle-valve. It is important that the exposure should only be made during the movement of the grid. It is advisable, therefore, to give a generous margin to the time of grid travel with respect to that of exposure. Fine stereoscopic pictures can be obtained with this apparatus, and, contrary to expectation, the tube shift can be made either diagonally across the lead strips or parallel with them.

A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1024. *Adsorption of Hydrogen by Quartz at Low Temperatures, − 190°.* **G. R. Paranjpe.** (Asiatic Soc. Bengal, Proc. 15. 136 and 137, 1919. From "Chem. Abstracts.")—The apparatus is a differential manometer, and the pressure difference due to unequal adsorption in two bulbs is measured by the volume change necessary to re-establish equilibrium. At − 190° a quartz surface of 100 cm.^{2} adsorbed at pressures ranging from 25 up to 350 mm. from 2 to 10·5 mm.^{3} of hydrogen. The correction which this adsorption demands for hydrogen thermometers of quartz is very small. Similar experiments were made with glass. H. B.

1025. *The Adsorption of Gas under Pressure.* **H. Briggs** and **W. Cooper.** (Roy. Soc. Edinburgh, Proc. 41. pp. 119–127, 1920–1921.)—Experiments are described and illustrated in graphs showing that at 15° C. with various adsorbents and gases (chiefly nitrogen and hydrogen) a cylinder filled with adsorbent granules has a capacity for dry gas under a given pressure which is generally greater than its capacity when containing no adsorbent. At 35 atmos. pressure a cylinder charged with nitrogen has its capacity increased by 66 % by filling it with coconut charcoal, but it is pointed out that at 120 atmos.—the pressure to which most commercial gas-cylinders are charged—the advantage to be gained by the charcoal is small. The need for dryness of both adsorbent and gas is emphasised. The experimental results are also applied to the consideration of sudden outbursts of firedamp in coal-mines which are shown to be the result of releasing immense quantities of gas adsorbed under pressure in coal. The logarithmic relation derived by A. M. Williams is shown to apply to the adsorption isotherms of gases above their critical temperature up to pressures of 100 atmos., providing a correction be applied for the gas in the capillaries which is not adsorbed, but which exists under simple compression. A. B. C. L.

1026. *Adsorption of Gas by Charcoal, Silica, and other Substances.* **H. Briggs.** (Roy. Soc., Proc. 100. pp. 88–102, Oct. 4, 1921.)—A method of determining the adsorptive capacity of a substance at liquid air temperature is described and the results are given of experiments on a number of substances, including various charcoals and silica. Of the mineral substances tried meerschaum proved the best, though its capacity at − 190° C. is greatly inferior to that of the better kinds of charcoal and silica. Preparations of colloidal alumina and stannic acid are found to be of little value. The best method found for the preparation of a high-capacity silica is described. A table is given showing the preferential adsorption of hydrogen, as compared with nitrogen, by charcoal and carbonaceous adsorbents as compared with silica. The effect of the compressibility of the initial layer, when the density of an adsorbent is determined by the immersion method, is considered. An evaluation is made of (*a*) the volume of solid matter, (*b*) that of the interstitial space between the granules, and (*c*) that of the internal gaseous space, for silica and coconut charcoal. The density of the nitrogen adsorbed at − 190° C. by silica and charcoal is calculated from experimental data. From these results it becomes possible roughly to estimate the error

affecting the density of charcoal ascertained from water immersion. The conditions affecting adsorption at low and high saturations are set forth. The presence of capillaries is not sufficient to account for adsorption. A high-capacity silica may be de-activated, and in the inactive state it remains porous. Graphite, which has no pores, adsorbs gas at − 190° C. The evidence leads to the conclusion that de-activated silica is vitreous. It is argued that a vitreous solid, like a crystal, is a polymer, i.e. a complete atomic linkage. The importance of distinguishing between the coarser capillaries or canals and the finer interpolymeral openings of an adsorbent is emphasised. Activation is considered to be the effect of disrupting the solid polymers, and the means of accomplishing the partial depolymerisation of charcoal and silica is described.
A. B. C. L.

1027. *Synthetic Helium and Neon.* **A. Lo Surdo.** (Accad. Lincei, Atti, 30. i. pp. 85–88, Feb. 6, 1921.)—It is shown experimentally that neon, helium, and hydrogen are able to pass through hot glass, the hydrogen in far greater quantity than the other two gases. This phenomenon depends on the temperature of the glass and hence on the nature of the discharge, and on various other factors such as the quality and thickness of the glass. These results may furnish an explanation of the origin of so-called synthetic helium and neon [Abs. 1033 (1913)], which may be derived from the atmosphere. T. H. P.

1028. *A Method for the Micro-Analysis of Gases by the Use of the Pirani Pressure Gauge.* **Research Staff of the General Electric Co., London.** (Phys. Soc., Proc. 33. pp. 287–296 with Disc., Aug., 1921.)—(1) A method of analysis of gases at a pressure between 0·1 and 0·001 mm. is described, based on the characteristic vapour-pressure–temperature curve of any substance.

(2) The method demands a gauge which will measure the pressures of vapours, as well as of permanent gases, over the range mentioned. The Pirani gauge is suitable for this purpose, especially if it is used in a way which is not new, but of which the advantages have not been sufficiently recognised. AUTHORS.

1029. *Production of Single Crystals of Aluminium and their Tensile Properties.* **H. C. H. Carpenter** and **C[onstance] F. Elam.** (Roy. Soc., Proc. 100. pp. 329–353, Dec. 1, 1921.)—Metals and alloys generally contain 150 to 300 crystals per linear unit. Sykes observed up to 5000 in molybdenum wire [Abs. 711 (1922)]. On the other hand, local deformation followed by heating gives large crystals, and lamp filaments of tungsten may consist of a single crystal. The authors had previously [Abs. 1170 (1921)] produced large crystals in sheet aluminium of 98·9 per cent., and they describe similar experiments with 8·75 in., ⅛ in. thick, of cold-rolled Al of 99·6 per cent., containing 0·19 Si and 0·14 Fe. Heated at 550° C. for 6 hours, this metal contained 150 crystals per in. and the whole specimen therefore about 1,687,000 crystals, which then all coalesced to one or a few crystals. The regrowth had seemed to demand that every crystal in the complex should be stressed to a certain small amount and one of them more than the rest; it had also appeared unlikely that this condition would occur in practice. But they found in their new experiments with the pure Al that one-fourth of the test pieces

were converted, each into one single crystal, and that most of the others contained only 2, 3, or 4 crystals. After being heated as mentioned, the specimen is stretched by a load of 0·3 ton, corresponding to 2·4 tons per sq. in., which produced an elongation of 1·6 per cent. on the test length of 3 in. The specimen is then placed in a furnace at 450° and the temperature raised in 48 to 72 hours, finally to 600°, when one crystal will have been formed. Whilst the ultimate strength of the original specimen ranged from 4·5 to 4·7 tons per sq. in. and the elongation on 3 in. from 36 to 38 per cent., the single crystals, which possessed very remarkable malleability, had a strength of 2·8 to 4·08 tons and the elongation varied between 39 and 86 per cent. These large variations in properties were accompanied by variations in the mode of stretching and in the type of fracture; the authors distinguish five of these types, by which specimens consisting of 2 or 3 crystals can also be classified. The British Aluminium Co. further supplied the authors with test bars 0·564 and 0·798 in. in diameter. They were likewise converted into single (or a few) crystals; the difficulties were greater for the thicker specimens. Under tensile stress the round bars assumed an elliptic and a lenticular cross-section, and finally showed peculiar fractures. Fracture occurred across the one or more crystals occupying the cross-section, not along boundaries. On reheating broken specimens the least deformed produced the largest crystals, the new crystals growing from the fracture itself, from scratches on the surface, or from crystal and twin boundaries.
H. B.

1030. *Preparation and Study of Single-Crystal Wires. Zinc.* **E. v. Gomperz.** (Zeits. f. Physik, 8. 3. pp. 184–190, 1922.)—In order to study the properties of wires of single crystals, the author melts the metal, *e.g.*, zinc, in a tubular quartz vessel, 4 cm. diameter, closed by a cork through which passes a metal tube, ending below in a capillary perforated rod. The rod is lowered into the melt and then slowly raised by means of an electric motor, while nitrogen is sent through the tubes; a disc of mica, perforated in the centre, floats on the fused metal. Wires about 35 cm. in length, from 0·1 to 1·5 mm. in diam., are thus produced, fairly uniform in cross-section. In the cases of Zn and of Bi each wire forms a single crystal, as the character of the plane of rupture indicates; in the cases of Pb, Sn, Al, Cd, Rb, this is not certain yet. The wires may be classed as either ductile or brittle. Ductile zinc wires are obtained when the metal is heated about 25 deg. above its melting-point, and the wire is drawn at rates of about 0·1 to 0·2 mm. per second. On the Schopper textile testing machine these wires can be stretched to 5 times their original length, the expansion with increasing load being first rapid and then slow, but quite regular; the originally-round wires flatten out during this tension test. The brittle wires are obtained when the metal is superheated by not more than 5 deg. and the rate of drawing is raised to 0·5 or 1 mm. per sec.; these wires do not expand by more than 8 per cent., and the elongation takes place in steps. This jerky expansion was regarded as characteristic of intercrystalline displacements, whilst the extraordinary elongation of the ductile wires is novel for ordinary temperature, though known for some steel at 160° (le Chatelier). The tensile strength of the ductile wire is several hundred times larger than that of ordinary wires.
H. B.